STATE OF CONNECTICUT.

SIXTH ANNUAL REPORT

—OF THE—

STORRS

AGRICULTURAL EXPERIMENT STATION,

STORRS, CONN.

1893

Printed by Order of the General Assembly.

MIDDLETOWN, CONN.:
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PUBLICATIONS OF THE STATION.

The publications of the Station will be mailed to all citizens of Connecticut, and to Granges, Farmers' Clubs, and other agricultural organizations who ask for them, and so far as circumstances permit, to those who apply from other States. Requests for publications should be addressed to

STORRS AGRICULTURAL
EXPERIMENT STATION,
STORRS, CONN.

Tolland County.

CONTENTS.

The Station is located at Mansfield (P. O. Storrs), as a department of the Storrs Agricultural College. The chemical and other more abstract work is carried out at Wesleyan University, Middletown.

OFFICERS OF THE STATION.

EXECUTIVE COMMITTEE.

T. S. GOLD, West Cornwall, J. M. HUBBARD, Middletown,	*Of the Board of Trustees of Storrs Agricultural College.*
B. F. KOONS, Storrs,	*President of the College.*

TREASURER.

HENRY C. MILES, Milford.

STATION STAFF.

W. O. ATWATER, Middletown,	*Director.*
C. D. WOODS, Middletown,	*Vice-Director and Chemist.*
C. S. PHELPS, Storrs,	*Agriculturist.*
E. B. FITTS, Storrs,	*Assistant in Farm Experiments.*

Report of the Executive Committee.

To His Excellency Luzon B. Morris,

Governor of Connecticut:

In accordance with the resolution of the General Assembly concerning the congressional appropriations to Agricultural Experiment Stations, and an Act of the General Assembly, approved March 6th, 1889, relating to the publication of Reports of the Storrs Agricultural Experiment Station, we have the honor to present herewith the Sixth Annual Report of that Station, namely, that for the year 1893.

The Committee refer to the accompanying report of the Treasurer for details of expenditure, and to that of the Director and his associates for the history of the work accomplished, and express their confident belief that the funds have been wisely expended and that the work is such as will result in great benefit to our agricultural interests.

Respectfully submitted,

T. S. GOLD,
J. M. HUBBARD,
B. F. KOONS,
Executive Committee.

Report of the Treasurer

FOR THE FISCAL YEAR ENDING JUNE 30, 1893.

The following summary of receipts and expenditures is made out in accordance with the form recommended by the Association of American Agricultural Colleges and Experiment Stations, and approved by the United States Treasury Department:

TABULAR STATEMENT OF RECEIPTS AND EXPENDITURES.

RECEIPTS.

U. S. Treasury,	$7,500 00
Sale of produce,	500 87
Balance from 1891-92,	130 55
	$8,131 42

EXPENDITURES.

Salaries,	$4,481 99
Building,	19 75
Traveling expenses,	329 01
Executive Committee,	97 34
Stationery,	122 51
Postage, telegraph and telephone,	131 31
Treasurer,	51 40
Fixtures, permanent,	56 67
Fixtures, not permanent,	25 91
Bulletins and reports,	165 00
Library,	2 00
Field experiments,	331 74
Team,	46 13
Feeding experiments,	175 77
Student and other labor,	89 53
Apparatus, immediate,	400 86
Apparatus, permanent,	959 49

Chemicals,	$93 28
Coal, gas and oil,	193 34
Hardware and lumber,	16 36
Freight, express and cartage,	157 07
Dietary investigations,	39 52
Bacteriological investigations,	87 23
Incidentals,	54 45
Balance in Treasury,	3 76
	$8,131 42

HENRY C. MILES,
Treasurer.

This certifies that we have examined the accounts of Henry C. Miles, Treasurer of the Storrs Agricultural Experiment Station, for the fiscal year ending June 30th, 1893, and compared them with the vouchers, and find the same correct. The balance in hands of the Treasurer on June 30th, 1893, amounted to Three Dollars and Seventy-six cents ($3.76).

E. LIVINGSTON WELLS, } *Auditors of*
OSCAR LEACH, } *Public Accounts.*

HARTFORD, December 26th, 1893.

Report of the Director

FOR THE YEAR 1893.

The principal lines of inquiry prosecuted during the past year may be concisely stated as follows:

1. Meteorological observations.
2. Field experiments with fertilizers.
3. Experiments on the growth of forage plants.
4. Feeding experiments with sheep.
5. Digestion experiments with sheep.
6. Studies of rations fed to milch cows on dairy farms in Connecticut.
7. Studies of bacteria and their action in the ripening of cream.
8. Analyses of feeding stuffs.
9. Investigations of materials used for the food of man. Analyses of foods exhibited at the World's Fair.
10. Investigations of dietaries.
11. Experiments with the bomb calorimeter.
12. Development of a respiration calorimeter.

The larger part of the work done during the year is in continuation of that described in previous reports of the Station. The digestion experiments with sheep; the studies of the feeding practice of Connecticut dairymen; the investigations of foods undertaken at the World's Fair in behalf of the Columbian Commission; and the work with the bomb and respiration calorimeters represent new inquiries. The new work, like much of that previously begun, has to do chiefly with the chemistry of nutrition.

For an institution with an annual income of only $7,500 per year, which is the whole amount received by the Storrs Station

from public sources, so wide a range of subjects of investigation might seem inexcusable. The justification is found in two facts. One is that the several lines of investigation upon the food and nutrition of animals and man are more or less nearly parallel with each other and are so conducted as to form really one department of inquiry. The other is that a considerable part of the work is done with little or no expense to the Station treasury. Free use is had of rooms and apparatus in the chemical laboratory of Wesleyan University, whose trustees are desirous of promoting scientific research, especially that of the more abstract kind to which an already large and gradually increasing part of the investigations belongs. The calorimetric investigations especially are of this order. The studies of dietaries are made in coöperation with the U. S. Department of Labor, which bears a large part of the expense. The cost of the investigations of foods exhibited at the World's Fair is borne mainly by the Bureau of Awards of the Columbian Commission. Considerable sums have been given from time to time by private individuals in aid of different parts of the more purely scientific inquiry. Though these sums have been placed in charge of the treasurer of Wesleyan University they have been applied directly to the payment of the expenses of the inquiries, the results of which have been and are to be published in the Reports of the Station. And finally, a considerable amount of service has been rendered gratuitously. This is notably the case with the bacteriological investigations of Prof. Conn which bear so directly upon the dairy industry. It is certainly the belief of many friends of the Station that its efficiency is doubled by what comes to it outside of the government appropriation.

Abstract research is the necessary foundation of the most useful knowledge and a large amount of it is being carried on in connection with the work of the Station. Partly because we have but little completed research of this kind to report now, and partly because it is of less interest to practical men, almost none is given here. The whole of the contents of the present Report have to do with things of everyday interest. And I may add that while the subjects reported upon bring less of new conclusions than have been found in several previous Annual Reports, no year in the history of the Station has been marked by so much of active and really fruitful work. The following brief statements will give an idea of the character of the year's work.

FIELD EXPERIMENTS WITH FERTILIZERS.

As in preceding years, these have been conducted upon the Station land and by farmers upon their own farms in different parts of the State in coöperation with the Station. "The object aimed at is to study the soils of different regions, learn their deficiencies, and find how to apply fertilizers so as to meet the needs of particular soils and crops in an economical way." The results of the year's work are given by Professor Phelps upon pages 119 to 139 of this Report. Owing to the drought in mid-summer, the results are not so striking as they have been in other years.

The experiments by Mr. Dean of Lime Rock are particularly instructive. They cover a period of five years during which the same plots have received the same fertilizers but have borne different crops in different years. The principal lessons taught are summarized by Professor Phelps as follows:

"(1). The necessity of preparing fertilizers so as to meet the needs of soils.

"(2). The importance of stocking light, porous soils with a large amount of organic nitrogen in order to supply nitrogen to the crop and get the best results from the mineral fertilizers.

"(3). The value and economy of legumes for improving light, porous soils by plowing in as manure.

"(4). The evidence that soluble phosphates may prove a detriment to the crop on certain light soils, unless there is an abundance of available nitrogen present in the soil In the absence of available nitrogen, the phosphates seem to hasten maturity and thus shorten the life of the plant. This is a probable explanation of the way the phosphoric acid diminishes the yield."

A summary of the results of fifteen years' experimenting by soil tests with fertilizers on farms throughout New England, was given in Bulletin No. 10 of the Station, and in the Annual Report for 1892.

FORAGE PLANTS.

The question of forage plants for Connecticut farming has been studied by the Station ever since its establishment. Different species and varieties are grown in small areas in the Forage Garden, and those which seem to be worthy of special study are cultivated on a larger scale. During the past two or three years especial attention has been given to the effects of nitrogenous

fertilizers upon the composition of the crop. The results upon grasses up to 1892 were given in pages 60-66 of the Report of the Station for that year. It is found not only that nitrogenous fertilizers increase the total yield of grasses, but also that the percentage of protein in them is larger, so that the value of the crop is increased in a two-fold way.

During 1893 especial attention was given to legumes. This work will be repeated and enlarged the coming year, and the results are accordingly reserved for later publication. Meanwhile it may be said that the experience of the Station serves to emphasize and explain the importance of leguminous plants. The statements (See Bulletin 6 of the Station) will bear constant repetition, that the legumes are especially valuable because of:—

1. Their large percentage of protein compounds which serve to form blood, muscle, bone and milk, and their consequent feeding value, which exceeds that of the grasses, corn fodder, corn stover, or straws. They may be used to supplement these fodders, in place of the concentrated nitrogenous feeds, such as bran, cotton seed, linseed, and gluten meals, etc. Hay from the legumes is twice or more than twice as rich in protein as that from the grasses.

2. Their power of gathering large quantities of plant food from natural sources. Many, if not all of our common legumes acquire considerable quantities of nitrogen from the air. Their roots penetrate deeply into the subsoil, and they thus obtain plant food from depths beyond the reach of plants with smaller root development.

3. Their manurial value. When the crop is fed, most of the nitrogen, phosphoric acid, potash and other fertilizing ingredients go into the excrement, liquid and solid, and if preserved, make a rich manure. If the crop is plowed under, its plant food, including that acquired from the air and gathered from the subsoil, becomes available for succeeding crops. The large amounts of plant food left behind in roots and stubble after the removal of the crop, furnish a cheap and valuable store of plant food for following crops.

Among the legumes which the experience of the Station leads us to commend for trial in the State are clovers, including scarlet clover, cow peas, vetch and soy beans.

FEEDING EXPERIMENTS WITH SHEEP.

The object of these has been to observe the effects of different kinds of food upon the production of fat and lean flesh in sheep. Lambs of the same age and breed and as nearly alike as could be obtained, were divided into three groups, numbered one, two and three. Those of group three were butchered at the beginning of the experiment. The other two groups were fed for three months upon different rations; group two having a "narrow" ration (rich in protein), and group three a "wide" ration (rich in carbohydrates). The results are given by Messrs. Woods and Phelps on pages 28-42 of the present Report. The work is being continued during the winter of 1893-4, and the details of the practical deductions are reserved for future publication. In general it appears that, as was to be expected from experiments elsewhere, a reasonably large allowance of protein in the fodder is desirable. The results tend to confirm the belief that Connecticut farmers need to increase the proportion of nitrogen in their feeding stuffs.

DIGESTION EXPERIMENT WITH SHEEP.

The greatest difficulty in the experiments just referred to on feeding sheep with mixed rations was to calculate the amount of food actually digested by the animals. In order to overcome this difficulty as far as possible, several digestion experiments with the same kinds of food were undertaken with animals of the same breed, age and weight as those of the feeding experiment. This study was begun in the fall of 1893. The results could not be made ready for printing in the present Report. They are therefore reserved for later publication.

BACTERIA IN THE RIPENING OF CREAM.

During the past six years investigations on the Bacteria of Milk have been conducted in behalf of the Station by H. W. Conn, Professor of Biology in Wesleyan University.* The results of practical trials of artificial cultures upon the ripening of cream and other related topics are discussed by Prof. Conn upon pages 43–68 of this Report. The principal points are there summarized as follows:

* Some of the results have been given in the publications of the Station, as follows: Bacteria in Milk, Cream and Butter, Bulletin 4, and Annual Report for 1889, pp. 52-67. Ripening of Cream, Annual Report for 1890, pp. 136-157. A Micrococcus of Bitter Milk, Report for 1891, pp. 158-162. The Isolation of Rennet from Bacteria Cultures, Report for 1892, pp. 106-126. See also The Fermentations of Milk, Experiment Station Bulletin No. 9 of the Office of Experiment Stations of the U. S. Department of Agriculture.

1. Different species of bacteria grown in the cream while ripening have different effects upon the butter flavor. The differences in the resulting butter aroma are not very prominent in most cases, but are decided enough to make the difference between a first-class grade of butter and a second-class.

2. Pasteurizing cream at 70° C. (*i.e.*, heating to 158° Fahrenheit for two or three minutes), will so largely destroy the bacteria in it, that a pure culture of bacteria subsequently inoculated will produce its proper effects, not materially affected by the few organisms left in the cream after pasteurization.

3. Most species of bacteria found in cream of a good creamery produce good butter. The number which injure the flavor of the butter is small.

4. No one species of those experimented with, when used alone for ripening cream, produces a typically flavored butter, though many of them produce butter which is excellent in flavor and which was preferred to that of the normal ripening.

One species of bacteria for ripening cream has been furnished to three creameries. At the time of the present writing the experience with it has covered a period of several weeks in each of two, and nearly four months in one, of the creameries, that in Cromwell, Conn. The managers report most gratifying results. Those with the longest experience are the most enthusiastic. In the Cromwell creamery the use of a culture furnished by Prof. Conn has greatly improved the quality of the butter. There seems to be the best reason to expect that bacteria cultures may be made a most important help in butter-making. With the right bacteria the finest butter, that with the most desirable aroma and flavor, can be made. It ought to become possible to select the desirable kinds of bacteria and supply them for use and thus improve the quality of our butter, just as our field and garden crops and fruits have been improved by selection of the best varieties. If experience justifies this expectation the benefit to dairying will be very great.

RATIONS FED TO MILCH COWS IN CONNECTICUT.

During the winter of 1892-3 a Station representative visited sixteen different dairy farms in different parts of the State, and studied the methods practiced in the management of their herds. Information was obtained regarding:—number of animals kept; breed, age and weight of each cow; period of lactation; milk flow

at each milking; percentage and weight of fat in milk; weight of each kind of feeding stuff fed per cow per day, and the chemical composition of the feeding stuffs.

A full description of these tests, together with a practical discussion of the results is given by Messrs. Woods and Phelps on pages 69-115 of this Report. Statements of rations actually fed are summarized on pages 103-115, with suggestions of changes that might be made and of particular rations for special cases.

This is only the beginning of an effort by the Station to coöperate directly with dairymen in the study of the methods of feeding their cows and the ways by which improvements may be made. The purpose of this work is parallel with that of the coöperative field experiments by farmers for studying the effects of fertilizers upon the crops grown on their own farms. The experiments with fertilizers have proven most useful from both the educational and the practical standpoints. It is hoped that the work on methods of feeding may be equally so.

FEEDING STUFFS USED IN NEW ENGLAND.

On pages 140–173 Mr. Woods has summarized briefly the results of the analyses of feeding stuffs grown in New England and the grains chiefly used for feeding in the same section. He has also summarized the results of tests of the digestibility of these materials by experiments with animals in Europe and in the United States, and has added a short explanation of the methods employed in calculating rations.

ANALYSES OF FEEDING STUFFS.

A considerable number of feeding stuffs have been analyzed in connection with feeding experiments upon the growth of plants. The results of 146 analyses, together with brief descriptions of the specimens, are given on pages 17–27 of this Report.

INVESTIGATIONS OF FOODS. ANALYSES OF FOOD MATERIALS EXHIBITED AT THE WORLD'S FAIR.

In connection with the studies of dietaries, a considerable number of food materials have been analyzed. The principal work in this direction during the past year, however, has been in the analyses of foods exhibited at the World's Fair.

As a member of the Jury of Awards at the Fair the writer was assigned to the department which included food products, and was requested by the Executive Committee on Awards to take

charge of an examination of some of the more interesting and important materials there exhibited. This investigation was made in accordance with the purpose of the World's Columbian Commission, which was to make the Fair educational and to provide that its influence should continue after the Fair itself should end. Probably no other occasion has offered such an opportunity for comparison of materials used for the nutrition of man. Certainly none has been so favorable for collecting specimens of food materials which are most interesting to us in the United States. An examination of cereal grains was made under the direction of Professor Wiley, Chemist in the U. S. Department of Agriculture. The prepared food products as such, including especially the animal foods, were assigned to myself.

By the courtesy of the authorities of the University of Chicago, the use of the chemical laboratory of that institution was given for the investigation. In order to save the expense of apparatus and the time required for preparing it, the trustees of the Storrs Station authorized the use of its material for the purpose, and more than a ton of packages of apparatus and chemicals was shipped from Middletown to Chicago and used in the investigation. Mr. Woods, the Vice-Director of the Station, assumed for a time the immediate charge of the analyses. Messrs. H. B. Gibson, H. M. Smith, F. W. Frost, A. E. Loveland, and H. M. Burr, who had been previously connected with the work of the Experiment Station or with that of the chemical laboratory of Wesleyan University; and Dr. C. F. Langworthy and Mr. E. L. Sturtevant, who have since become associated with the chemical laboratory, and Mr. O. S. Blakeslee of the physical laboratory, accompanied me to Chicago to share in the work. The services of a number of other gentlemen were secured so that, all told, 16 chemists, representing 12 American and foreign colleges and universities, were occupied there for a longer or shorter time during the summer. Somewhat over 600 specimens of food materials were collected. The analyses were made, so far as possible, in Chicago during the Fair. At its close the work was transferred to Middletown, where it has been continued with the aid of the Station and of Wesleyan University. Analyses of 500 specimens have been completed and a report of the work is now being prepared. The investigation is thus more extensive than any previously undertaken.

STUDIES OF DIETARIES.

These have been of the same general character as those described in previous Reports of the Station and are in continuation of an investigation which is being made by coöperation with the U. S. Department of Labor.

INVESTIGATIONS OF THE BOMB CALORIMETER.

The study of food and nutrition has brought us to a point where it is essential to learn the fuel value of food materials, or in other words, the amounts of potential energy which they contain and which may be changed to heat or the muscular power or other form of energy in the body. The apparatus for this purpose is called the calorimeter. Investigations with a form of calorimeter were described in the Report for 1890. A form which has proven more satisfactory is the so-called bomb calorimeter. Hitherto the only satisfactory bomb calorimeter has been that of Berthelot, but its great cost, $1,000 or more, which is due to the large quantity of platinum required for its construction, has prevented its general use. With the aid of Prof. Hempel, of Dresden, I have succeeded in obtaining a bomb calorimeter which costs not more than $100 or $200, and proves quite satisfactory. The effort is now being made to devise one which shall be less expensive.

RESPIRATION CALORIMETER.

Research upon nutrition has brought us to the point where the study of the application of the laws of the conservation of matter and of energy in the living organism are essential. That is to say, we must be able to determine the balance of income and outgo of the body, and this balance must be expressed both in terms of matter and of energy. For this purpose a respiration calorimeter is being devised. This is an apparatus in which an animal or a man may be placed for a number of hours or days and the amounts and composition of the food and drink and inhaled air; the amounts and composition of the excreta, solid, liquid and gaseous; the potential energy of the materials taken into the body and given off from it; the quantity of heat radiated from the body; and the mechanical equivalent of the muscular work done are all to be measured. The experimenting is complicated, costly and time-consuming. The results already obtained are, however, very encouraging in their promise of future success.

W. O. Atwater.

RESULTS OF ANALYSES OF FODDERS AND FEEDING STUFFS.

BY CHAS. D. WOODS.

In connection with the work of the Station, analyses of the following miscellaneous feeding stuffs have been made by the Station chemists. For the most part the analyses were made in connection with feeding experiments or experiments upon the growth of plants. In no case were they undertaken merely to increase the amount of this class of data. The methods of analyses recommended by the Association of Official Chemists were employed.

The results of the analyses as calculated to water content at harvest or at the time of analyses are given in table 1, page 21, which follows the description of samples. In this table the materials are grouped somewhat according to their water content at time of taking samples as follows: Green fodders; silage; field-cured hay; cured hay and fodder; grain; and milling products. This order is also observed in the descriptions of samples.

The results calculated to water-free (dry matter) as the basis are given in table 2, page 24.

The potential energy, or fuel value, of a pound of each of the feeding stuffs as given in the tables, was obtained by multiplying the number of hundredths of a pound of protein and of carbohydrates by 18.6, and the number of hundredths of a pound of fat by 42.2, and taking the sum of these three products as the number of calories of potential energy in the materials.*

DESCRIPTION OF SAMPLES.

In the description of samples the same order of arrangement is observed as in table 1.

GREEN FODDERS.

1218–1221, *Oat Grass (Avena elatior).*—Grown in grass garden in 1893. The sample was taken June 24th, at which time the seeds were beginning to form. There was a fair yield of quite pure oat grass. No. 1218 was from a plot without fertilizers. No. 1219 was from a plot supplied with dissolved bone-black at the rate of 320 pounds per acre, and with muriate of potash at the rate

* See article on fuel value of feeding stuffs, Report of this Station, 1890, pages 174–181.

of 160 pounds. No. 1220 was from a plot to which "mixed minerals" were applied as in 1219, and had in addition 160 pounds of nitrate of soda per acre. No. 1221 was grown on a plot to which mixed minerals were applied as in 1219, and had in addition 480 pounds of nitrate of soda per acre.

1222–1225, *Fescue Grass (Festuca elatior)*.—Grown in the grass garden of the Station in 1893. The samples were taken June 24th, at which time the grass was in full bloom. No. 1222 was from a plot without fertilizers. No. 1223 was from a plot to which there were applied dissolved bone-black at the rate of 320 pounds per acre and muriate of potash at the rate of 160 pounds. No. 1224 was grown on a plot to which mixed minerals were applied as in 1223, and had in addition 160 pounds of nitrate of soda per acre. No. 1225 was grown on a plot to which mixed minerals were applied as in 1221, and had in addition 480 pounds of nitrate of soda per acre.

1226–1229, *Orchard Grass (Dactylis glomerata)*.—Grown in the grass garden of the Station in 1893. The samples were taken June 24th, at which time the grass was a little past bloom. No. 1226 was grown without the use of fertilizers. No. 1227 was from a plot to which there were applied dissolved bone-black at the rate of 320 pounds per acre and muriate of potash at the rate of 160 pounds. No. 1228 was grown on a plot to which mixed minerals were applied as in 1227, and had in addition 160 pounds of nitrate of soda per acre. No. 1229 was grown on a plot to which mixed minerals were applied as in 1227, and had in addition 480 pounds of nitrate of soda.

1230–1233, *Timothy (Phleum pratense)*.—Grown in the Station grass garden in 1893. The samples were taken July 1st, at which time the grass was in early bloom. No. 1230 was grown without the use of fertilizers. No. 1231 was from a plot to which there were applied dissolved bone-black at the rate of 320 pounds per acre and muriate of potash at the rate of 160 pounds. No. 1232 was grown on a plot to which mixed minerals were applied as in 1231, and had in addition 160 pounds of nitrate of soda per acre. No. 1223 was grown on a plot to which mixed minerals were applied as in 1231, and had in addition 480 pounds of nitrate of soda per acre.

1234–1245, *Cow Pea Vines (Dolichos sinensis)*.—Grown in a soil test experiment on the Station grounds in 1893. Nos. 1234, 1235 and 1236 were from plots which received no fertilizers. The plot from which 1237 was taken received nitrate of soda at the rate of 320 pounds per acre; that of 1238, dissolved bone-black at the rate of 320 pounds per acre; 1239, muriate of potash at the rate of 160 pounds per acre; 1240, 160 pounds of nitrate of soda and 320 pounds of dissolved bone-black per acre; 1241, 160 pounds of nitrate of soda and 160 pounds of muriate of potash per acre; 1242, 320 pounds of dissolved bone-black and 160 pounds of muriate of potash; 1243, 160 pounds of nitrate of soda, 320 pounds of dissolved bone-black, and 160 pounds of muriate of potash per acre. No. 1244 was from a plot which received six tons of stable manure and 160 pounds of dissolved bone-black, and 1245 was from a plot which received six tons of stable manure per acre.

1246–1248, *Cow Pea Vines (Dolichos sinensis)*.—No. 1246 was grown without the use of fertilizers. No. 1247 was from a plot to which there were applied dissolved bone-black at the rate of 320 pounds per acre, muriate of potash at the rate of 160 pounds and nitrate of soda at the rate of 160 pounds. No. 1248 was

grown on a plot to which there were applied dissolved bone-black at the rate of 320 pounds per acre, muriate of potash at the rate of 160 pounds and nitrate of soda at the rate of 480 pounds per acre.

ENSILAGE.

1115, *Corn Ensilage.*—Sample taken in connection with milch cow ration No. 1.* Common yellow Canada corn. Good ears picked off before cutting.

1123, *Corn Ensilage.*—Sample taken in connection with milch cow ration No. 2. White southern corn, planted very thick and cut before eating.

1142, *Corn Ensilage.*—Sample taken in connection with milch cow ration No. 5. Butler's early dent corn. Ears picked off before harvesting.

1183, *Corn Ensilage.*—Sample taken in connection with milch cow ration No. 12. White southern corn.

FIELD CURED CROPS.

1249-1261, *Hungarian Grass (Setaria Italica).*—Grown by the Station in a special nitrogen experiment in 1893. Nos. 1249 and 1250 were grown without the use of fertilizers. Nos. 1251 and 1252 were grown upon plots to which were applied dissolved bone-black at the rate of 320 pounds per acre and muriate of potash at the rate of 160 pounds. Nos. 1253, 1254 and 1255 were grown upon plots to which was applied in addition to the mixed minerals of the preceding, nitrate of soda at the rate of 160, 320 and 480 pounds per acre. Nos. 1256, 1257 and 1258 were grown upon plots which had, in addition to the mixed minerals, sulphate of ammonia at the rate of 120, 240 and 360 pounds per acre respectively. Nos. 1259, 1260 and 1261 were grown upon plots which had, in addition to the mixed minerals, ammonite at the rate of 192, 384 and 576 pounds per acre respectively per acre.

1127, 1137, 1144, 1150, 1153, 1168, 1176, 1188, 1194, 1198, 1205, 1210, *Mixed Hay.*—Samples taken in connection with milch cow rations Nos. 2, 4, 5, 6, 7, 10, 11, 12, 13, 14.

1156, *Mixed Hay.*—Sample taken in connection with milch cow ration No. 8. Hay unlike ordinary farm hay, being almost entirely from a large lawn.

1163, *Mixed Hay.*—Sample taken in connection with milch cow ration No. 9. Mostly timothy.

1211, *Mixed Hay.*—Sample taken in connection with milch cow ration No. 16. Poor quality, used cut up with stover.

1126, *Mixed Hay.*—Sample taken in connection with milch cow ration No. 2. Meadow hay of poor quality.

1120, *Timothy and Red-top Hay.*—Sample taken in connection with milch cow ration No. 1. Rather late cut.

1132, *Timothy and Red-top Hay.*—Sample taken in connection with milch cow ration No. 3. Early cut of good quality.

1162 and 1169, *Rowen Hay.*—Samples taken in connection with milch cow rations Nos. 9 and 10.

1178, *Rowen Hay.*—Used in sheep feeding experiment by the Station. Mostly grasses, one-sixth to one-fourth clover.

1121, *Oat Hay.*—Sample taken in connection with milch cow ration No. 1. Cut in bloom.

1149 and 1174, *Oat Hay.*—Sample taken in connection with milch cow rations Nos. 6 and 11. In each case the crop was cut for grain, but was used for hay.

* See article beyond on rations actually fed to milch cows.

MILLING PRODUCTS.

1146, 1158, 1164, 1171, 1186 and 1192, *Corn Meal.*—From samples taken in connection with milch cow rations Nos. 6, 9, 10, 11, 12, 13.*

1181, *Corn Meal.*—Sample taken in connection with sheep feeding experiment by the Station.

1135, 1155, 1202, 1209 and 1214, *Cob Meal.*—Corn and cob ground together. These samples were taken in connection with milch cow rations Nos. 2, 8, 15, 16 and 17. No. 1209 consisted of a mixture of twelve bushels of native corn on the ear and of four bushels of western corn.

1116, 1136, 1154, 1160, 1166, 1173, 1187, 1197, 1203 and 1208, *Wheat Bran.*—Samples taken in connection with milch cow rations Nos. 1, 4, 8, 9, 10, 11, 12, 14, 15 and 16.

1180, *Wheat Bran.*—Samples taken in connection with sheep feeding experiment by the Station.

1119, 1122, 1141, 1145, 1151, 1172, 1193 and 1213, *Wheat Middlings.*—These samples were taken in connection with milch cow rations Nos. 1, 2, 5, 6, 7, 11, 13 and 17.

1129, *Rye Bran.*—Sample taken in connection with milch cow ration No. 3.

1200, *Rye Meal.*—Sample taken in connection with milch cow ration No. 15.

1182, *Old Process Linseed Meal.*—Sample taken in connection with sheep feeding experiment by the Station.

1118 and 1201, *Old Process Linseed Meal.*—Samples taken in connection with milch cow rations Nos. 1 and 15.

1131, 1134, 1143, 1147, 1157, 1165, 1170, 1184 and 1191, *Cotton Seed Meal.*—Samples taken in connection with milch cow rations Nos. 3, 4, 7, 9, 10, 11, 12 and 13.

1179, *Pea Meal.*—Sample taken in connection with sheep feeding experiment by the Station.

1117, 1128 and 1207, *Buffalo Gluten Meal.*—Samples taken in connection with milch cow rations Nos. 1, 3 and 16.

1124, 1140, 1159 and 1196, *Chicago Gluten Meal.*—Samples taken in connection with milch cow rations Nos. 2, 5, 9 and 14.

1130, *Hominy Chop, Hominy Feed, Hominy Meal or Baltimore Meal.*—Sample taken in connection with milch cow ration No. 3.

1185, *Malt Sprouts.*—Sample taken in connection with milch cow ration No. 12.

1195 and 1204, *Oat Feed.*—Refuse from oat meal factory. Samples taken in connection with milch cow rations Nos. 14 and 15.

1125 and 1152, *Provender (Corn and Oats).*—The provender was claimed to consist of two-thirds corn and one-third oats, ground together. Samples taken in connection with milch cow rations Nos. 2 and 7.

1189, *Sheep Feed.*—Sample of the grain and ensilage mixture which was being used by Mr. Charles Lyman of Middlefield in the winter of 1892. The mixture was made as follows: Corn ensilage, 4000 pounds; bran, 350 pounds; linseed meal, 150 pounds; corn, 1000 pounds; pea meal, 1000 pounds.

1139, *Shorts and Skim Milk.*—Mr. Edward Atkinson of Boston, in experimenting with the utilization of separator skim milk, evaporated it with wheat bran in the proportion of two parts of milk to one of bran by weight. The loss from evaporation was such that 16 parts of the mixture gave 7 parts of the feed.

* See article beyond on rations actually fed to milch cows.

TABLE I.

Proximate Composition of Fodders and Feeding Stuffs.—Results of Analyses Herewith Reported, Calculated to Water Content at Time of Taking Sample.

Lab. No.	KIND.*	Water.	Protein.	Fat.	Nit.-free Ext.	Fiber.	Ash.	Potential En'gy.
	Green Fodders.	%	%	%	%	%	%	Calor's per lb.
1218	Avena elatior, - -	65.91	2.62	1.06	16.06	11.94	2.41	615
1219	Avena elatior, - -	67.75	2.39	1.01	14.80	11.67	2.38	580
1220	Avena elatior, - -	68.95	3.33	1.10	13.73	10.70	2.19	565
1221	Avena elatior, - -	68.76	4.29	1.14	13.37	10.14	2.30	565
	Average, - -	**67.84**	**3.16**	**1.08**	**14.49**	**11.11**	**2.32**	**580**
1222	Festuca elatior, -	70.99	2.17	.76	13.44	10.58	2.06	520
1223	Festuca elatior, -	71.29	2.23	.82	13.22	10.34	2.10	515
1224	Festuca elatior, -	74.44	2.67	.68	11.02	9.22	1.97	455
1225	Festuca elatior, -	76.28	3.35	.77	9.73	7.90	1.97	425
	Average, - -	**73.25**	**2.61**	**.76**	**11.85**	**9.51**	**2.02**	**479**
1226	Dactylis glomerata, -	65.33	2.89	1.23	15.50	12.61	2.44	625
1227	Dactylis glomerata, -	65.64	2.66	1.18	15.47	12.41	2.64	615
1228	Dactylis glomerata, -	71.77	3.38	1.09	11.89	9.43	2.44	505
1229	Dactylis glomerata, -	76.45	3.96	1.05	9.10	7.35	2.09	425
	Average, - -	**69.80**	**3.22**	**1.14**	**12.99**	**10.45**	**2.40**	**545**
1230	Phleum pratense, -	71.32	2.27	.94	13.86	9.88	1.73	520
1231	Phleum pratense, -	72.62	2.11	.77	13.13	9.60	1.77	495
1232	Phleum pratense, -	73.23	2.41	.74	12.38	9.58	1.66	485
1233	Phleum pratense, -	74.24	3.07	.77	11.48	8.86	1.58	470
	Average, - -	**72.85**	**2.47**	**.81**	**12.71**	**9.48**	**1.68**	**495**
1234	Cow pea vines, -	80.81	3.28	.72	9.12	3.83	2.24	330
1235	Cow pea vines, -	82.45	3.37	.65	7.73	3.52	2.28	300
1236	Cow pea vines, -	81.25	3.53	.58	8.28	3.94	2.42	320
1237	Cow pea vines, -	82.32	3.01	.61	8.59	3.51	1.96	305
1238	Cow pea vines, -	81.58	3.49	.60	8.33	3.73	2.27	315
1239	Cow pea vines, -	84.01	3.16	.56	6.84	3.25	2.18	270
1240	Cow pea vines, -	82.59	3.00	.63	8.22	3.47	2.09	300
1241	Cow pea vines, -	84.62	2.46	.53	6.93	3.48	1.98	260
1242	Cow pea vines, -	82.95	3.39	.61	7.00	3.84	2.21	290
1243	Cow pea vines, -	84.55	2.78	.55	6.59	3.44	2.09	265
1244	Cow pea vines, -	82.83	3.29	.61	7.52	3.68	2.07	295
1245	Cow pea vines, -	83.83	2.92	.60	7.20	3.46	1.99	280
1246	Cow pea vines, -	86.07	3.03	.58	5.36	3.05	1.91	235
1247	Cow pea vines, -	86.62	2.82	.55	5.07	3.08	1.86	230
1248	Cow pea vines, -	86.28	2.75	.63	5.55	3.16	1.63	240
	Average, - -	**83.53**	**3.08**	**.60**	**7.22**	**3.49**	**2.08**	**280**
	Ensilage.							
1115	Corn ensilage, -	80.18	1.91	.83	10.54	5.16	1.38	360
1123	Corn ensilage, -	81.35	1.34	.54	9.51	6.16	1.10	335
1142	Corn ensilage, -	61.54	2.33	1.11	22.19	10.40	2.43	695
1183	Corn ensilage, -	83.69	1.74	.69	7.58	5.30	1.00	300
1190	Corn ensilage, -	83.99	1.08	.67	8.81	4.55	.90	295
	Average, - -	**78.15**	**1.68**	**.77**	**11.73**	**6.31**	**1.36**	**395**

* For description of samples, see pages 17–19.

TABLE I.—(*Continued.*)

Lab. No.	KIND.*	Water.	Protein.	Fat.	Nit.-free Ext.	Fiber.	Ash.	Potential En'gy.
	Field Cured Hay.	%	%	%	%	%	%	Calor's per lb.
1249	Hungarian grass, -	25.15	6.05	2.55	39.68	21.95	4.62	1370
1250	Hungarian grass, -	24.55	7.41	2.43	38.22	22.44	4.95	1370
1251	Hungarian grass, -	34.69	5.53	1.93	33.18	19.86	4.81	1170
1252	Hungarian grass, -	31.67	6.33	2.03	33.98	20.60	5.39	1240
1253	Hungarian grass, -	29.13	5.72	1.93	36.44	21.93	4.85	1270
1254	Hungarian grass, -	30.30	7.08	2.33	34.16	21.13	5.00	1260
1255	Hungarian grass, -	34.14	9.36	2.44	29.49	19.50	5.07	1185
1256	Hungarian grass, -	30.16	5.92	2.24	35.06	21.24	5.38	1250
1257	Hungarian grass, -	33.46	5.76	1.84	32.69	21.05	5.20	1185
1258	Hungarian grass, -	34.94	7.10	2.04	30.12	20.63	5.17	1160
1259	Hungarian grass, -	33.37	7.10	2.17	31.17	21.06	5.13	1195
1260	Hungarian grass, -	32.96	7.98	2.28	30.79	20.87	5.12	1205
1261	Hungarian grass, -	34.94	8.48	2.22	29.85	19.39	5.12	1165
	Average, - -	**31.50**	**6.91**	**2.18**	**33.45**	**20.90**	**5.06**	**1240**
	Cured Hay & Fodders.							
1215	Mixed hay and stover,	18.43	7.70	2.84	41.31	24.34	5.38	1485
1127	Hay, mixed, - -	14.97	7.76	2.94	41.81	27.37	5.15	1550
1150	Hay, mixed, - -	14.59	6.14	2.91	44.81	26.70	4.85	1565
1153	Hay, mixed, - -	13.73	7.60	3.30	45.90	23.99	5.48	1580
1156	Hay, mixed, - -	12.48	10.40	2.75	40.96	27.00	6.41	1575
1163	Hay, mixed, - -	21.39	5.94	1.98	39.49	26.30	4.90	1420
1168	Hay, mixed, - -	12.49	9.08	3.33	43.18	24.83	7.09	1575
1176	Hay, mixed, - -	12.38	6.90	2.33	38.09	34.74	5.56	1580
1177	Hay, mixed, - -	12.16	8.73	3.10	42.32	28.28	5.41	1605
1188	Hay, mixed, - -	13.24	9.27	3.80	43.76	23.81	6.12	1590
1194	Hay, mixed, - -	11.39	9.30	2.92	43.45	26.32	6.62	1595
1198	Hay, mixed, - -	15.39	8.56	3.66	42.76	23.17	6.46	1545
1205	Hay, mixed, - -	11.80	7.44	2.09	47.83	26.20	4.64	1605
1210	Hay, mixed, - -	15.94	7.20	3.10	45.28	23.45	5.03	1545
1211	Hay, mixed, - -	15.09	7.43	3.14	42.97	25.55	5.82	1545
1144	Hay, mixed, - -	15.52	8.55	2.71	38.41	29.20	5.61	1530
1126	Hay, mixed, - -	11.89	8.98	2.86	41.49	28.63	6.15	1595
1137	Hay, mixed, - -	18.54	7.33	3.30	41.52	23.32	5.99	1485
	Average, - -	**14.30**	**8.04**	**2.95**	**42.59**	**26.40**	**5.72**	**1560**
1120	Timothy and red-top,	12.28	7.73	3.07	42.91	29.08	4.93	1615
1132	Timothy and red-top,	15.30	5.51	2.96	45.28	26.81	4.14	1570
	Average, - -	**13.79**	**6.62**	**3.02**	**44.09**	**27.94**	**4.54**	**1595**
1162	Rowen hay, - -	21.62	12.69	3.53	35.06	21.21	5.89	1430
1169	Rowen hay, - -	15.13	12.84	3.41	39.86	22.13	6.63	1535
1178	Rowen hay, - -	13.73	12.89	3.08	39.99	25.24	5.07	1585
	Average, - -	**16.83**	**12.81**	**3.34**	**38.30**	**22.86**	**5.86**	**1515**
1121	Oat hay, - - -	14.77	8.21	2.63	38.21	29.61	6.57	1525
1149	Oat hay, - - -	14.58	5.66	2.82	43.85	28.70	4.39	1575
1174	Oat hay, - - -	26.86	8.50	3.41	42.60	15.10	3.53	1375
	Average, - -	**18.74**	**7.46**	**2.95**	**41.55**	**24.47**	**4.83**	**1490**
1133	Corn stover, - -	18.07	4.56	2.20	41.60	28.73	4.84	1485
1138	Corn stover, - -	31.86	6.25	1.63	33.36	22.60	4.30	1225
1148	Corn stover, - -	31.41	4.63	1.58	34.20	23.16	5.02	1220
1161	Corn stover, - -	15.10	6.47	1.41	42.89	27.48	6.65	1485
1167	Corn stover, - -	19.11	4.80	2.05	41.12	27.29	5.63	1450
1175	Corn stover, - -	18.58	4.68	1.76	40.24	29.95	4.79	1470

* For description of samples, see page 19.

TABLE I.—*(Continued.)*

Lab. No.	KIND.*	Water.	Pro-tein.	Fat.	Nit.-free Ext.	Fiber.	Ash.	Poten-tial En'gy.
	Cured Hay and Fodders.	%	%	%	%	%	%	Calor's per lb.
1199	Corn stover, - -	5.52	4.78	2.17	49.35	31.84	6.34	1690
1206	Corn stover, - -	16.64	3.91	1.50	42.71	29.02	6.22	1470
1212	Corn stover, - -	21.73	6.45	2.02	41.33	22.14	6.33	1385
	Average, - -	**19.78**	**5.17**	**1.81**	**40.76**	**26.91**	**5.57**	**1430**
	Milling Products.							
1146	Corn meal, - -	11.21	9.94	4.47	71.68	1.21	1.49	1730
1158	Corn meal, - -	11.86	8.48	4.95	72.11	.98	1.62	1730
1164	Corn meal, - -	13.24	7.71	4.89	70.79	1.83	1.54	1700
1171	Corn meal, - -	13.85	10.00	5.83	66.77	1.62	1.93	1700
1181	Corn meal, - -	14.60	8.80	4.92	67.94	2.48	1.26	1660
1186	Corn meal, - -	13.98	9.36	5.26	68.15	1.63	1.62	1695
1192	Corn meal, - -	9.29	9.80	4.70	72.70	1.81	1.70	1765
	Average, - -	**12.58**	**9.16**	**5.00**	**70.02**	**1.65**	**1.59**	**1710**
1135	Cob meal, - -	11.76	8.82	4.05	71.01	2.94	1.42	1715
1155	Cob meal, - -	14.26	10.29	4.34	65.50	3.60	2.01	1660
1202	Cob meal, - -	13.70	8.10	5.20	69.13	2.26	1.61	1700
1209	Cob meal, - -	14.53	8.23	4.57	69.75	1.51	1.41	1675
1214	Cob meal, - -	15.03	8.82	5.05	66.20	3.02	1.88	1665
	Average, - -	**13.86**	**8.85**	**4.64**	**68.32**	**2.66**	**1.67**	**1685**
1116	Wheat bran, - -	10.73	16.79	4.71	53.94	8.05	5.78	1665
1136	Wheat bran, - -	9.06	16.77	4.80	54.96	8.42	5.99	1695
1154	Wheat bran, - -	9.35	17.00	5.26	52.92	10.10	5.37	1710
1160	Wheat bran, - -	9.31	15.65	4.30	56.16	8.87	5.71	1700
1166	Wheat bran, - -	9.28	17.69	4.80	54.53	8.08	5.62	1695
1173	Wheat bran, - -	9.48	16.01	4.80	54.53	9.73	5.45	1695
1180	Wheat bran, - -	9.00	16.10	5.96	52.00	11.70	5.24	1735
1187	Wheat bran, - -	9.06	14.78	5.65	55.83	9.35	5.33	1730
1197	Wheat bran, - -	9.11	18.01	4.91	56.42	6.72	4.83	1715
1203	Wheat bran, - -	10.56	18.06	4.80	55.35	6.65	4.58	1695
1208	Wheat bran, - -	11.52	18.14	5.23	53.52	6.54	5.05	1675
	Average, - -	**9.68**	**16.82**	**5.02**	**54.56**	**8.56**	**5.36**	**1700**
1119	Wheat middlings, -	11.11	17.72	6.07	49.70	10.22	5.18	1700
1122	Wheat middlings, -	9.31	15.64	5.25	53.41	10.33	6.06	1700
1141	Wheat middlings, -	9.39	21.47	4.91	55.71	4.65	3.87	1730
1145	Wheat middlings, -	11.95	19.10	6.04	51.82	6.50	4.59	1695
1151	Wheat middlings, -	9.17	20.44	6.53	54.08	5.36	4.42	1760
1172	Wheat middlings, -	10.19	19.14	5.77	53.83	6.32	4.75	1720
1193	Wheat middlings, -	9.49	19.69	5.50	52.98	7.31	5.03	1720
1213	Wheat middlings, -	14.16	16.90	4.61	57.45	3.74	3.14	1645
	Average, - -	**10.60**	**18.75**	**5.59**	**53.62**	**6.81**	**4.63**	**1710**
1118	Linseed meal, - -	10.48	32.73	8.77	34.33	8.29	5.40	1775
1182	Linseed meal, - -	9.90	34.69	5.80	39.73	4.08	5.80	1705
1201	Linseed meal, - -	9.46	18.68	7.37	51.58	7.41	5.50	1755
	Average, - -	**9.95**	**28.70**	**7.31**	**41.88**	**6.59**	**5.57**	**1745**
1131	Cotton seed meal, -	7.29	42.93	9.05	27.72	6.03	6.98	1810
1134	Cotton seed meal, -	7.51	44.75	9.52	26.41	4.57	7.24	1810
1143	Cotton seed meal, -	6.97	44.48	14.00	24.84	2.78	6.93	1930
1147	Cotton seed meal, -	7.62	43.19	14.19	25.47	1.88	7.65	1910
1157	Cotton seed meal, -	16.25	42.98	14.72	15.59	2.81	7.65	1765

* For description of samples, see page 20.

TABLE 1.—(*Continued.*)

Lab. No.	KIND.*	Water.	Protein.	Fat.	Nit.-free Ext.	Fiber.	Ash.	Potential Eng'y.
	Milling Prod.--(Con.)	%	%	%	%	%	%	Calor's per lb.
1165	Cotton seed meal, -	6.48	42.68	11.47	28.09	3.68	7.60	1870
1170	Cotton seed meal, -	5.37	45.66	11.76	32.23	3.26	1.72	2010
1184	Cotton seed meal, -	6.52	44.00	10.00	28.79	3.60	7.09	1845
1191	Cotton seed meal, -	5.29	42.86	13.86	27.66	2.35	7.98	1940
	Average, - -	**7.70**	**43.73**	**12.06**	**26.31**	**3.44**	**6.76**	**1875**
1179	Pea meal, - -	11.02	26.69	1.50	53.93	3.28	3.58	1625
1117	Gluten meal, - -	8.44	24.16	11.90	49.21	5.32	.97	1965
1128	Gluten meal, - -	8.77	17.84	9.61	55.79	7.22	.77	1930
1207	Gluten meal, - -	9.60	11.81	13.92	57.73	5.69	1.25	1985
1124	Gluten meal, - -	9.10	38.58	4.74	45.14	1.59	.85	1785
1140	Gluten meal, - -	7.17	26.05	11.59	49.81	4.19	1.19	1980
1159	Gluten meal, - -	7.74	34.14	14.97	41.10	1.29	.76	2055
1196	Gluten meal, - -	7.71	36.05	13.55	40.92	1.17	.60	2025
	Average, - -	**8.36**	**26.95**	**11.47**	**48.53**	**3.78**	**.91**	**1960**
1130	Hominy chop, -	9.64	10.79	8.21	64.33	4.45	2.58	1825
1185	Malt sprouts, - -	10.21	25.09	2.04	44.10	12.31	6.25	1600
1195	Oat feed, - -	6.61	17.05	8.43	60.07	4.25	3.59	1870
1204	Oat feed, - -	7.55	16.93	8.37	57.00	5.98	4.17	1840
	Average, - -	**7.08**	**16.99**	**8.40**	**58.54**	**5.11**	**3.88**	**1855**
1125	Corn and oats, -	9.92	11.20	4.39	66.89	5.26	2.34	1735
1152	Corn and oats, -	10.63	9.83	4.48	70.28	2.43	2.35	1725
	Average, - -	**10.28**	**10.51**	**4.43**	**68.59**	**3.84**	**2.35**	**1730**
1129	Rye bran, - -	11.15	15.72	2.82	63.15	3.90	3.26	1660
1200	Rye meal, - -	12.43	8.97	1.72	74.11	1.49	1.28	1645
1189	Sheep feed, - -	48.16	8.42	1.77	32.68	6.69	2.28	965
1139	Shorts and skim milk,	9.14	22.94	4.68	49.45	7.60	6.19	1685

TABLE 2.

Proximate Composition of Fodders and Feeding Stuffs.—Results of Analyses Herewith Reported, Calculated to Water-free Substance (Dry Matter).

Lab. No.	KIND.*	Protein.	Fat.	Nit.-free Ext.	Fiber.	Ash.	Potential En'gy.
	Green Fodders.	%	%	%	%	%	Calor's per lb.
1218	Avena elatior, - - -	7.68	3.13	47.11	35.02	7.06	1800
1219	Avena elatior, - - -	7.42	3.12	45.90	36.17	7.39	1795
1220	Avena elatior, - - -	10.72	3.53	44.23	34.45	7.07	1810
1221	Avena elatior, - - -	13.74	3.64	42.80	32.46	7.36	1805
	Average, - - -	**9.89**	**3.35**	**45.01**	**34.53**	**7.22**	**1805**
1222	Festuca elatior, - - -	7.47	2.63	46.32	36.48	7.10	1790
1223	Festuca elatior, - - -	7.76	2.85	46.04	36.04	7.31	1790
1224	Festuca elatior, - - -	10.44	2.66	43.13	36.06	7.71	1780
1225	Festuca elatior, - - -	14.11	3.25	41.02	33.29	8.33	1785
	Average, - - -	**9.94**	**2.85**	**44.13**	**35.47**	**7.61**	**1785**
1226	Dactylis glomerata, - -	8.30	3.56	44.71	36.38	7.05	1815
1227	Dactylis glomerata, - -	7.73	3.45	45.01	36.13	7.68	1800

* For description of samples, see pages 17–20.

TABLE 2.—(*Continued.*)

Lab. No.	KIND.*	Pro-tein.	Fat.	Nit.-free Ext.	Fiber.	Ash.	Poten-tial En'gy.
	Green Fodders.—(Con.)	%	%	%	%	%	Calor's per lb.
1228	Dactylis glomerata, - -	11.97	3.86	42.08	33.42	8.67	1795
1229	Dactylis glomerata, - -	16.80	4.45	38.64	31.23	8.88	1805
	Average, - - -	**11.20**	**3.83**	**42.61**	**34.29**	**8.07**	**1805**
1230	Phleum pratense, - -	7.92	3.28	48.31	34.44	6.05	1825
1231	Phleum pratense, - -	7.72	2.80	47.95	35.06	6.47	1805
1232	Phleum pratense, - -	8.99	2.77	46.27	35.78	6.19	1810
1233	Phleum pratense, - -	11.93	2.98	44.58	34.39	6.12	1820
	Average, - - -	**9.14**	**2.96**	**46.77**	**34.92**	**6.21**	**1815**
1234	Cow pea vines, - - -	17.11	3.76	47.50	19.95	11.68	1735
1235	Cow pea vines, - - -	19.21	3.69	44.03	20.06	13.01	1705
1236	Cow pea vines, - - -	18.83	3.07	44.17	21.02	12.91	1695
1237	Cow pea vines, - - -	17.02	3.44	48.59	19.86	11.09	1735
1238	Cow pea vines, - - -	18.94	3.28	45.23	20.22	12.33	1710
1239	Cow pea vines, - - -	19.76	3.50	42.77	20.31	13.66	1690
1240	Cow pea vines, - - -	17.24	3.62	47.21	19.91	12.02	1720
1241	Cow pea vines, - - -	16.01	3.48	45.06	22.60	12.85	1705
1242	Cow pea vines, - - -	19.88	3.61	41.06	22.53	12.92	1705
1243	Cow pea vines, - - -	18.02	3.58	42.65	22.24	13.51	1695
1244	Cow pea vines, - - -	19.17	3.55	43.80	21.40	12.08	1720
1245	Cow pea vines, - - -	18.08	3.73	44.49	21.42	12.28	1720
1246	Cow pea vines, - - -	21.73	4.17	38.50	21.92	13.68	1705
1247	Cow pea vines, - - -	21.06	4.11	37.88	23.06	13.89	1700
1248	Cow pea vines, - - -	20.02	4.63	40.44	23.06	11.85	1745
	Average, - - -	**18.81**	**3.68**	**43.56**	**21.30**	**12.65**	**1712**
	Ensilage.						
1115	Corn ensilage, - - -	9.63	4.20	53.17	26.06	6.94	1830
1123	Corn ensilage, - - -	7.19	2.89	50.97	33.04	5.91	1820
1142	Corn ensilage, - - -	6.06	2.90	57.69	27.04	6.31	1810
1183	Corn ensilage, - - -	10.69	4.27	46.48	32.48	6.08	1850
1190	Corn ensilage, - - -	6.75	4.16	55.03	28.39	5.67	1855
	Average, - - -	**8.06**	**3.68**	**52.68**	**29.40**	**6.18**	**1835**
	Field Cured Hay.						
1249	Hungarian grass, - -	8.09	3.41	53.00	29.32	6.18	1825
1250	Hungarian grass, - -	9.82	3.22	50.65	29.74	6.57	1815
1251	Hungarian grass, - -	8.48	2.96	50.79	30.40	7.37	1795
1252	Hungarian grass, - -	9.26	2.98	49.73	30.14	7.89	1785
1253	Hungarian grass, - -	8.07	2.73	51.40	30.95	6.85	1795
1254	Hungarian grass, - -	10.16	3.35	49.01	30.31	7.17	1810
1255	Hungarian grass, - -	14.21	3.71	44.78	29.60	7.70	1805
1256	Hungarian grass, - -	8.48	3.21	50.20	30.40	7.71	1790
1257	Hungarian grass, - -	8.66	2.76	49.12	31.64	7.82	1780
1258	Hungarian grass, - -	10.92	3.13	46.29	31.71	7.95	1785
1259	Hungarian grass, - -	10.65	3.26	46.77	31.61	7.71	1795
1260	Hungarian grass, - -	11.90	3.40	45.93	31.14	7.63	1800
1261	Hungarian grass, - -	13.04	3.41	45.88	29.80	7.87	1795
	Average, - - -	**10.14**	**3.19**	**48.74**	**30.51**	**7.42**	**1800**
	Cured Hay and Fodders.						
1215	Mixed hay and stover, -	9.44	3.48	50.64	29.84	6.60	1820
1127	Hay, mixed, - - -	9.13	3.46	49.16	32.19	6.06	1830
1150	Hay, mixed, - - -	7.19	3.41	52.46	31.26	5.68	1835
1153	Hay, mixed, - - -	8.81	3.83	53.20	27.81	6.35	1830
1156	Hay, mixed, - - -	11.88	3.15	46.79	30.85	7.33	1800
1163	Hay, mixed, - - -	7.56	2.52	50.22	33.46	6.24	1800

* For description of samples, see pages 18 and 19.

TABLE 2.—*(Continued.)*

Lab. No.	KIND.*	Protein.	Fat.	Nit.-free Ext.	Fiber.	Ash.	Potential En'gy.
	Cured Hay, etc.—(Con.)	%	%	%	%	%	Calor's per lb.
1168	Hay, mixed,	10.38	3.81	49.33	28.37	8.11	1800
1176	Hay, mixed,	7.88	2.66	43.47	39.65	6.34	1805
1177	Hay, mixed,	9.94	3.53	48.18	32.19	6.16	1830
1188	Hay, mixed,	10.69	4.38	50.43	27.44	7.06	1835
1194	Hay, mixed,	10.50	3.30	49.02	29.70	7.48	1800
1198	Hay, mixed,	10.12	4.32	50.54	27.39	7.63	1820
1205	Hay, mixed,	8.44	2.37	54.23	29.70	5.26	1820
1210	Hay, mixed,	8.56	3.69	53.87	27.90	5.98	1835
1211	Hay, mixed,	8.75	3.70	50.60	30.09	6.86	1820
1144	Hay, mixed,	10.13	3.21	45.46	34.56	6.64	1815
1126	Hay, mixed,	10.19	3.25	47.09	32.49	6.98	1810
1137	Hay, mixed,	9.00	4.05	50.97	28.63	7.35	1820
	Average,	**9.36**	**3.45**	**49.71**	**30.80**	**6.68**	**1820**
1120	Timothy and red-top hay,	8.81	3.50	48.91	33.15	5.63	1840
1132	Timothy and red-top hay,	6.50	3.49	53.46	31.66	4.89	1850
	Average,	**7.65**	**3.50**	**51.18**	**32.41**	**5.26**	**1845**
1162	Rowen hay,	16.19	4.50	44.73	27.06	7.52	1825
1169	Rowen hay,	15.13	4.02	46.97	26.07	7.81	1810
1178	Rowen hay,	14.94	3.57	46.36	29.25	5.88	1835
	Average,	**15.42**	**4.03**	**46.02**	**27.46**	**7.07**	**1825**
1121	Oat hay,	9.63	3.09	44.82	34.74	7.72	1790
1149	Oat hay,	6.63	3.31	51.32	33.60	5.14	1845
1174	Oat hay,	11.63	4.66	58.24	20.64	4.83	1880
	Average,	**9.29**	**3.69**	**51.46**	**29.66**	**5.90**	**1835**
1133	Corn stover,	5.56	2.68	50.78	35.07	5.91	1815
1138	Corn stover,	9.18	2.39	48.95	33.17	6.31	1800
1148	Corn stover,	6.75	2.31	49.85	33.77	7.32	1780
1161	Corn stover,	7.63	1.66	50.51	32.37	7.83	1755
1167	Corn stover,	5.94	2.53	50.83	33.74	6.96	1790
1175	Corn stover,	5.75	2.16	49.42	36.79	5.88	1805
1199	Corn stover,	5.06	2.30	52.23	33.70	6.71	1790
1206	Corn stover,	4.69	1.81	51.23	34.81	7.46	1765
1212	Corn stover,	8.25	2.58	52.79	28.29	8.09	1770
	Average,	**6.54**	**2.27**	**50.73**	**33.52**	**6.94**	**1785**
	Milling Products.						
1146	Corn meal,	11.19	5.04	80.73	1.36	1.68	1945
1158	Corn meal,	9.63	5.62	81.80	1.11	1.84	1955
1164	Corn meal,	8.88	5.64	81.59	2.11	1.78	1960
1171	Corn meal,	11.63	6.77	77.48	1.88	2.24	1980
1181	Corn meal,	10.31	5.76	79.55	2.90	1.48	1970
1186	Corn meal,	10.88	6.12	79.21	1.90	1.89	1970
1192	Corn meal,	10.81	5.18	80.14	2.00	1.87	1950
	Average,	**10.48**	**5.73**	**80.07**	**1.89**	**1.83**	**1960**
1135	Cob meal,	10.00	4.59	80.47	3.33	1.61	1940
1155	Cob meal,	12.00	5.07	76.38	4.20	2.35	1935
1202	Cob meal,	9.38	6.03	80.10	2.62	1.87	1965
1209	Cob meal,	9.63	5.35	81.60	1.77	1.65	1960
1214	Cob meal,	10.38	5.95	77.90	3.56	2.21	1960
	Average,	**10.28**	**5.40**	**79.29**	**3.09**	**1.94**	**1950**
1116	Wheat bran,	18.81	5.28	60.42	9.02	6.47	1865
1136	Wheat bran,	18.44	5.28	60.43	9.26	6.59	1865
1154	Wheat bran,	18.75	5.81	58.37	11.14	5.93	1885
1160	Wheat bran,	17.25	4.75	61.92	9.78	6.30	1860

* For description of samples, see pages 19 and 20.

TABLE 2.—*(Continued.)*

Lab. No.	KIND.*	Protein.	Fat.	Nit.-free Ext.	Fiber.	Ash.	Potential En'gy.
	Milling Products.—(Con.)	%	%	%	%	%	Calor's per lb.
1166	Wheat bran,	19.50	5.29	60.10	8.91	6.20	1870
1173	Wheat bran,	17.69	5.30	60.24	10.75	6.02	1875
1180	Wheat bran,	17.69	6.55	57.14	12.86	5.76	1910
1187	Wheat bran,	16.25	6.22	61.38	10.29	5.86	1895
1197	Wheat bran,	19.82	5.40	62.07	7.40	5.31	1890
1203	Wheat bran,	20.19	5.37	61.88	7.44	5.12	1895
1208	Wheat bran,	20.50	5.91	60.48	7.40	5.71	1890
	Average,	**18.63**	**5.56**	**60.40**	**9.48**	**5.93**	**1880**
1119	Wheat middlings,	19.94	6.83	55.90	11.50	5.83	1910
1122	Wheat middlings,	17.25	5.79	58.88	11.39	6.69	1875
1141	Wheat middlings,	23.69	5.42	61.48	5.14	4.27	1910
1145	Wheat middlings,	21.69	6.86	58.86	7.38	5.21	1925
1151	Wheat middlings,	22.50	7.19	59.54	5.90	4.87	1940
1172	Wheat middlings,	21.31	6.42	59.94	7.04	5.29	1910
1193	Wheat middlings,	21.75	6.08	58.53	8.08	5.56	1900
1213	Wheat middlings,	19.69	5.38	66.91	4.36	3.66	1920
	Average,	**20.98**	**6.25**	**60.00**	**7.60**	**5.17**	**1910**
1118	Linseed meal,	36.56	9.80	38.35	9.26	6.03	1980
1182	Linseed meal,	38.50	6.44	44.09	4.53	6.44	1890
1201	Linseed meal,	20.63	8.14	56.97	8.19	6.07	1935
	Average,	**31.89**	**8.13**	**46.47**	**7.33**	**6.18**	**1935**
1131	Cotton seed meal,	46.31	9.76	29.90	6.50	7.53	1950
1134	Cotton seed meal,	48.38	10.30	28.55	4.94	7.83	1960
1143	Cotton seed meal,	47.81	15.05	26.70	2.99	7.45	2080
1147	Cotton seed meal,	46.75	15.36	27.57	2.04	8.28	2070
1157	Cotton seed meal,	51.31	17.58	18.62	3.36	9.13	2105
1165	Cotton seed meal,	45.63	12.26	30.03	3.95	8.13	2000
1170	Cotton seed meal,	48.25	12.43	34.06	3.44	1.82	2120
1184	Cotton seed meal,	47.07	10.72	30.78	3.85	7.58	1970
1191	Cotton seed meal,	45.25	14.63	29.20	2.49	8.43	2045
	Average,	**47.42**	**13.12**	**28.38**	**3.73**	**7.35**	**2035**
1179	Pea meal,	30.00	1.68	60.61	3.69	4.02	1825
1117	Gluten meal,	26.38	13.00	53.74	5.82	1.06	2150
1128	Gluten meal,	19.56	10.54	61.15	7.91	.84	2090
1207	Gluten meal,	13.06	15.40	63.86	6.29	1.39	2200
1124	Gluten meal,	42.44	5.21	49.66	1.75	.94	1965
1140	Gluten meal,	28.06	12.48	53.65	4.52	1.29	2130
1159	Gluten meal,	37.00	16.23	44.54	1.40	.83	2225
1196	Gluten meal,	39.06	14.68	44.33	1.27	.66	2195
	Average,	**29.36**	**12.51**	**52.99**	**4.14**	**1.00**	**2135**
1130	Hominy chop,	11.94	9.09	71.19	4.92	2.86	2025
1185	Malt sprouts,	27.94	2.27	49.11	13.71	6.97	1785
1195	Oat feed,	18.25	9.03	64.31	4.56	3.85	2000
1204	Oat feed,	18.31	9.06	61.64	6.47	4.52	1990
	Average,	**18.28**	**9.04**	**62.98**	**5.51**	**4.19**	**1995**
1125	Corn and oats,	12.44	4.87	74.25	5.84	2.60	1925
1152	Corn and oats,	11.00	5.01	78.64	2.72	2.63	1930
	Average,	**11.72**	**4.94**	**76.44**	**4.28**	**2.62**	**1930**
1129	Rye bran,	17.69	3.18	71.07	4.39	3.67	1870
1200	Rye meal,	10.25	1.97	84.61	1.70	1.47	1880
1189	Sheep feed,	16.25	3.42	63.03	12.90	4.40	1860
1139	Shorts and skim milk,	25.25	5.15	54.42	8.37	6.81	1855

* For description of samples, see pages 19–24.

FEEDING EXPERIMENT WITH SHEEP.

BY CHAS. D. WOODS AND C. S. PHELPS.

The experiment was undertaken in order to observe the effects of different kinds of food upon the chemical composition of the flesh of sheep.

PLAN OF THE EXPERIMENT.

The plan consisted in selecting a number of sheep of the same breed and age, and as nearly alike as possible, and dividing them into three groups. One group was to be butchered at the beginning of the experiment and the flesh analyzed. The results of the weighings and analysis of this group would serve to indicate more or less accurately the condition of the other animals at the beginning of the experiment. The two other groups were to be fed differently, one upon a wide ration (relatively deficient in protein), the other upon a narrow ration* (relatively rich in protein). At the end of the experiment the animals were to be all butchered and as complete analysis of the flesh made as should seem advisable.

DETAILS OF THE EXPERIMENT.

Early in December, 1892, 12 grade Shropshire wethers of the preceding spring were purchased for the experiment. They were bred and raised in Vermont, and had been at pasture very nearly up to the time of purchase by the Station. They were in average condition as regards fatness. Soon after the animals were received at the Station they were divided into two lots of about uniform total weights. The sheep were all closely sheared Dec. 10. December 29 one animal was selected from each lot for immediate slaughter and analysis. Each of the ten remaining animals was placed in a pen by itself, though the grouping was kept up as before. At this date (Dec. 29) five animals (Nos. 3-7) in the group which were intended to be fed the "wide

* In order that a ration may be complete there must be enough digestible protein in the food to build new tissues (bone, muscle, wool, etc.) and repair the wastes of the body, and sufficient digestible fat and carbohydrates to furnish heat and muscular energy. If the sum of the digestible carbohydrates and two and a half times the digestible fat of a ration is divided by the amount of digestible protein in the ration, the quotient gives what is called the nutritive ratio. If the quantities of digestible fat and carbohydrates are large relative to the protein this number will be large, and the ration is called a "wide ration;" if the quantities of digestible fat and carbohydrates are relatively small the quotient is a small number and the ration is a "narrow" one. A ration where the nutritive ratio is much more than 1 : 6 is called a "wide ration;" if much less, it is called a "narrow ration." "Wide rations" are more common among American feeders than are "narrow" ones.

ration" weighed 362 pounds, and the five animals (Nos. 8–12) which were to be fed the "narrow" ration weighed 361 pounds. The first week after the separation of the animals there were quite marked differences in their apparent growth. One animal in each group gained, but on the whole the animals lost in weight so that on January 5th, when the feeding experiment actually began, the animals of the wide ration group (Nos. 3–7) weighed 356½ pounds, and those of the narrow ration group (Nos. 8–12) weighed 355 pounds.

The two animals (Nos. 1 and 2) which had been selected for slaughter at the commencement of the experiment were kept together until Jan. 5, when they were butchered. In the meantime they had also changed in weight. December 29 No. 1 weighed 73 pounds, and on Jan. 5th, when butchered, it weighed 74 pounds, and No. 2, which weighed 72 pounds on Dec. 29, had decreased in weight to 69 pounds on Jan. 5.

By this arrangement the group slaughtered at the beginning of the actual experiment consisted of two animals, while the two groups which were fed had five each. It would have been more satisfactory to slaughter and analyze five for the measure of the amount and composition of the flesh at the beginning, but the pressure of work at the time made so large a number of weighings and analyses difficult, and furthermore the whole experiment was regarded as preliminary to more extended series of trials and one of its objects was to get experience; hence the smaller number was taken. The figures in the following tabulation indicate that the average weights of the animals of the three groups at the beginning of the actual experiment, January 5th, were nearly the same.

Average Weights of Sheep of Different Groups at Beginning and End of Preliminary Period of One Week.

	SLAUGHTERED.	FED.	
	Two Sheep. Nos. 1 and 2.	Wide Ration. Five Sheep. Nos. 3–7.	Narrow Ration. Five Sheep. Nos. 8–12.
December 29th,	72.5 lbs.	72.4 lbs.	72.2 lbs.
January 5th,	71.5 lbs.	71.3 lbs.	71.0 lbs.

The actual feeding experiment continued until March 29th, eighty-four days.

It should be explained that as the animals were kept in separate pens they were more or less restive. One was very much so, as stated beyond, and it seems probable that with this animal at any rate, the result of the experiment was affected by the nervous condition of the animal.

KINDS AND AMOUNTS OF FOOD.

The animals in the wide ration group, Nos. 3 to 7, were fed a ration of hay, turnips and corn meal. Those of the narrow ration group, Nos. 8 to 12, were fed rowen hay with a grain mixture of linseed meal, pea meal, wheat bran and corn meal. The rations fed each animal are shown in table 3. In each group the grain ration at the end of five weeks was increased by a half pound per animal. The total weight of feed, exclusive of the turnips, was the same in each group, 4 pounds per day per animal for the first five weeks and 4½ pounds per day per animal for the remaining eight weeks.

TABLE 3.

Kinds and Amounts of Food Furnished Each Animal in Sheep Feeding Experiment of 1893.

KIND OF FOOD.	Fed from Jan. 5 to Feb. 9, inclusive (36 days). Each day.	Fed from Jan. 5 to Feb. 9, inclusive (36 days). Total in 36 days.	Fed from Feb. 10 to March 29, inclusive (48 days). Each day.	Fed from Feb. 10 to March 29, inclusive (48 days). Total in 48 days.	Total fed from Jan. 5 to March 29, inclusive (84 days).
Sheep Nos. 3–7.—Wide Ration.	Ozs.	Lbs.	Ozs.	Lbs.	Lbs.
Corn meal,	16	36	24	72	108
Hay,	32	72	32	96	168
Turnips,	24	54	24	72	126
	72	162	80	240	402
Sheep Nos. 8–12.—Narrow Ration.					
Linseed meal,	2	4.5	4	12	16.5
Pea meal,	6	13.5	12	36	49.5
Wheat bran,	4	9	4	12	21
Corn meal,	4	9	4	12	21
Rowen hay,	32	72	32	96	168
	48	108	56	168	276

PERCENTAGE COMPOSITION OF FEEDING STUFFS USED.

Samples of the grain and hay fed in the experiment were taken from time to time, and from these samples smaller sub-samples were obtained at the end of the experiment for the purpose of analysis. The uneaten residues of food of each animal were carefully collected each day and weighed. The uneaten residues of each group were kept by themselves, and at the end of the experiment samples of each were taken for analysis. The percentage composition of the feeding stuffs and of the uneaten residues are shown in table 4, which follows.

TABLE 4.

*Percentage Composition of Feeding Stuffs Used and of Uneaten Residues in Sheep Feeding Experiment of 1893.**

Lab. No.	KIND OF FEEDING STUFF.	Water.	Protein.	Fat.	Nit.-free Ext.	Fiber.	Ash.
		%	%	%	%	%	%
1182	Linseed meal, - - - -	9.90	34.69	5.80	39.73	4.08	5.80
1179	Pea meal, - - - -	11.02	26.69	1.50	53.93	3.28	3.58
1180	Wheat bran, - - -	9.00	16.10	5.96	52.00	11.70	5.24
1181	Corn meal, - - - -	14.60	8 80	4.92	67.94	2.48	1.26
1177	Hay, - - - - -	12.16	8.73	3.10	42.32	28.28	5.41
1178	Rowen hay, - - -	13.73	12.89	3.08	39.99	25.24	5.07
	Turnips,† - - - -	89.10	1.10	.30	7.30	1.20	1.00
	Uneaten Residues.						
1217	From wide ration, - -	59.89	4.69	1.31	19.13	12.26	2.72
1216	From narrow ration, - -	61.20	7.96	1.05	17.44	9.27	3.08

* For composition calculated on water-free basis, see pages 25–27, this Report.
† Not analyzed. Averages of four analyses of New England grown ruta-bagas.

The amount of digestible nutrients was calculated by using the following factors (digestion co-efficients):

	Protein.	Fat.	CARBOHYDRATES.	
			Nitrogen–Free Extract.	Fiber.
	%	%	%	%
Linseed meal, - - - - -	90†	94†	96†	93†
Pea meal, - - - - -	83*	54*	94*	26*
Wheat Bran, - - - - -	78*	73*	66*	33†
Corn meal, - - - - -	76*	92*	87*	58†
Hay (good quality), - - -	54*	54*	63*	55*
Rowen hay, - - - -	62†	46†	67†	64†
Turnips, - - - - -	84*	77*	95*	80*

* From American digestion experiments.
† From German digestion experiments.

Table 5 gives the rations fed and the total and digestible nutrients in the food. In the case of the wide ration the turnips are not included in this table. The sheep differed very much in the way in which they ate turnips. Only one or two of the animals ate them very well, the others eating only a small part of the quantity fed. Each day the turnips uneaten were weighed so that at the end it was possible to tell exactly what weight of turnips was eaten by each animal. These weights will be found in table 6 with the other details of the experiment.

TABLE 5.

Rations Fed. Total Nutrients and Digestible Nutrients in Rations Used in Sheep Feeding Experiment of 1893.

KIND OF FOOD.	Total Weight Fed.	TOTAL NUTRIENTS IN FOOD.				DIGESTIBLE NUTRIENTS.		
		Protein.	Fat.	Nitrogen-free ext.	Fiber.	Protein.	Fat.	Carbohydrates*
Sheep 3–7.—Wide Ration.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Cornmeal,	108.0	9.5	5.3	73.3	2.7	11.2	4.9	65.3
Hay,	168.0	14.7	5.2	71.1	47.5	7.9	2.8	70.9
Turnips,†	—	—	—	—	—	—	—	—
Total in corn meal and hay for 84 days,	276.0	24.2	10.5	144.4	50.2	19.1	7.7	136.2
Sheep 8–12.—Narrow Ration.								
Linseed meal,	16.5	5.7	1.0	6.5	.7	5.1	.9	6.9
Pea meal,	49.5	13.2	.7	26.7	1.6	11.0	.4	25.5
Wheat bran,	21.0	3.4	1.2	10.8	2.5	2.7	.9	8.0
Corn meal,	21.0	1.8	1.0	14.2	.5	1.4	.9	12.6
Rowen hay,	168.0	21.6	5.2	67.0	42.4	13.3	2.4	72.0
Total fed,	276.0	45.7	9.1	125.2	47.7	33.5	5.5	125.0

* The carbohydrates include the digestible fiber and nitrogen-free extract.
† See under each animal in table 6, which follows.

Table 6 shows the total and digestible nutrients actually eaten by each animal through the whole period, and also the averages for each day. The total nutrients and the digestible nutrients furnished in grain and hay are taken from table 5. The total and digestible nutrients in the uneaten residue of grain and hay are subtracted from these weights in the case of each animal. The remainders show the total and digestible nutrients furnished by grain and hay which were actually eaten. In the case of the wide ration group, Nos. 3-7, varying quantities of turnips were

eaten, and the total and digestible nutrients in the turnips eaten have been added to those of the grain and hay actually eaten. This sum gives the total eaten in the eighty-four days that the experiment lasted. Dividing the totals by eighty-four gives the averages per day.

The uneaten residues consisted of the coarser and less digestible portions of the hay, together with some grain. The grain would be more digestible than the hay, but the rejected portions of the hay were much less digestible than the whole hay, consequently it was thought that it would not be far from the truth to assume the same digestion co-efficients for the uneaten residues as for the hay used in the experiments.

Of course the estimates of amounts of digestible nutrients, which are based upon averages of experiments elsewhere, are merely estimates and must be taken for what they are worth. In experiments now being made (winter of 1893–4) the digestibility of the feeding stuffs is being tested by direct experiments with sheep.

Since the digestion co-efficients are estimated rather than actually determined, the error introduced in estimating the digestibility of the uneaten residues is less significant.

Table 7, on page 36, summarizes the total and digestible nutrients eaten by the sheep in this experiment. Wolff's (German) standard for fattening sheep calls for a ration, per 100 pounds live weight, of .30 pounds of digestible protein and sufficient digestible fat and carbohydrates to make the total energy (fuel value) equal to 3,520 calories, with a nutritive ratio of 1 to 5.5. The average of 11 experiments with 122 animals, conducted in experiment stations in five states in the United States, gives a ration, per 100 pounds of live weight, of .27 of a pound of digestible protein with sufficient digestible fat and carbohydrates to furnish 3,560 calories of energy with a nutritive ratio of 1 to 6.1. The total energy (fuel value) of each of the rations in the experiments here reported upon differs but little from either of the above. In the case of the wide ration the protein is considerably below the standard and the narrow ration is very much above the average as found in other sheep feeding experiments. It will be noticed that the narrow ration is narrower than the average of the American rations above cited, and that in the case of the wide ration, it is a good deal wider.

TABLE 6.

Estimated Total and Digestible Nutrients in Food Eaten by Each Animal in Sheep Feeding Experiment of 1893.

	Total Nutrients.				Digestible Nutrients.		
	Protein.	Fat.	Nit.-free Ext.	Fiber.	Protein.	Fat.	* Carbohydrates.
WIDE RATION.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Sheep No. 3.							
Furnished in grain and hay,	24.2	10.5	144.4	50.2	19.1	7.7	136.2
Uneaten residue of grain and hay (32.3 lbs.), -	1.5	.4	6.2	4.0	.8	.2	6.1
Eaten:—							
In grain and hay, - -	22.7	10.1	138.2	46.2	18.3	7.5	130.1
In turnips (67.6 lbs.), -	.7	.2	4.9	.8	.6	.2	1.2
Total eaten in 84 days, -	23.4	10.3	143.1	47.0	18.9	7.7	131.3
Average per day, - -	.279	.123	1.704	.560	.225	.092	1.563
Sheep No. 4.							
Furnished in grain and hay,	24.2	10.5	144.4	50.2	19.1	7.7	136.2
Uneaten residue of grain and hay (7.3 lbs.), -	.3	.1	1.4	.9	.2	.1	1.4
Eaten:—							
In grain and hay, - -	23.9	10.4	143.0	49.3	18.9	7.6	134.8
In turnips (78.7 lbs.), -	.8	.2	5.7	.2	.6	.2	5.6
Total eaten in 84 days, -	24.7	10.6	148.7	49.5	19.5	7.8	140.4
Average per day, - -	.299	.126	1.770	.589	.232	.093	1.671
Sheep No. 5.							
Furnished in grain and hay,	24.2	10.5	144.4	50.2	19.1	7.7	136.2
Uneaten residue of grain and hay (51.1 lbs.), -	2.4	.7	9.8	6.3	1.3	.4	9.6
Eaten:—							
In grain and hay, - -	21.8	9.8	134.6	43.9	17.8	7.3	126.6
In turnips (23 lbs.), -	.2	—	1.7	.2	.2	—	1.6
Total eaten in 84 days, -	22.0	9.8	136.3	44.1	18.0	7.3	128.2
Average per day, - -	.262	.117	1.623	.525	.214	.087	1.526
Sheep No. 6.							
Furnished in grain and hay,	24.2	10.5	144.4	50.2	19.1	7.7	136.2
Uneaten residue of grain and hay (32.5 lbs.), -	1.5	.4	6.2	4.0	.8	.2	6.1
Eaten:—							
In grain and hay, - -	22.7	10.1	138.2	46.2	18.3	7.5	130.1
In turnips (23.1 lbs.), -	.2	—	1.7	.2	.2	—	1.6
Total eaten in 84 days, -	22.9	10.1	139.9	46.4	18.5	7.5	131.7
Average per day, - -	.273	.120	1.665	.552	.220	.089	1.568

* The carbohydrates include both the digestible fiber and nitrogen-free extract.

TABLE 6.—*(Continued.)*

	Total Nutrients.				Digestible Nutrients.		
	Protein.	Fat.	Nit.-free Ext.	Fiber.	Protein.	Fat.	* Carbohydrates.
WIDE RATION.—*(Con.)* *Sheep No. 7.*	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Furnished in grain and hay,	24.2	10.5	144.4	50.2	19.1	7.7	136.2
Uneaten residue of grain and hay (26.1 lbs.), -	1.2	.3	5.0	3.2	.7	.3	4.9
Eaten:—							
In grain and hay, - -	23.0	10.2	139.4	47.0	18.4	7.4	131.3
In turnips (124.8 lbs.), -	1.4	.4	9.1	1.5	1.2	.3	9.8
Total eaten in 84 days, -	24.4	10.6	148.5	48.5	19.6	7.7	141.1
Average per day, - -	**.290**	**.126**	**1.768**	**.577**	**.233**	**.092**	**1.680**
NARROW RATION. *Sheep No. 8.*							
Furnished in grain and hay,	45.7	9.1	125.2	47.7	33.5	5.5	125.0
Uneaten residue of grain and hay (34.3 lbs.), -	2.7	.4	6.0	3.2	1.7	.2	6.1
Total eaten in 84 days, -	43.0	8.7	119.2	44.5	31.8	5.3	118.9
Average per day, - -	**.512**	**.104**	**1.419**	**.530**	**.379**	**.063**	**1.415**
Sheep No. 9.							
Furnished in grain and hay,	45.7	9.1	125.2	47.7	33.5	5.5	125.0
Uneaten residue of grain and hay (18.3 lbs.), -	1.5	.2	3.2	1.7	.9	.1	3.2
Total eaten in 84 days, -	44.2	8.9	122.0	46.0	32.6	5.4	121.8
Average per day, - -	**.526**	**.106**	**1.452**	**.548**	**.388**	**.064**	**1.450**
Sheep No. 10.							
Furnished in grain and hay,	45.7	9.1	125.2	47.7	33.5	5.5	125.0
Uneaten residue of grain and hay (0.4 lbs.), - -	.1	—	.2	—	—	—	.1
Total eaten in 84 days, -	45.6	9.1	125.0	47.7	33.5	5.5	124.9
Average per day, - -	**.543**	**.108**	**1.488**	**.568**	**.399**	**.065**	**1.487**
Sheep No. 11.							
Furnished in grain and hay,	45.7	9.1	125.2	47.7	33.5	5.5	125.0
Uneaten residue of grain and hay (26.1 lbs.), -	2.0	.3	4.5	2.4	1.2	.1	4.5
Total eaten in 84 days, -	43.7	8.8	120.7	45.3	32.3	5.4	120.5
Average per day, - -	**.520**	**.105**	**1.437**	**.539**	**.385**	**.064**	**1.435**
Sheep No. 12.							
Furnished in grain and hay,	45.7	9.1	125.2	47.7	33.5	5.5	125.0
Uneaten residue of grain and hay (2.2 lbs.), - -	.1	—	.4	.2	.1	—	.4
Total eaten in 84 days, -	45.6	9.1	124.8	47.5	33.4	5.5	124.6
Average per day, - -	**.543**	**.108**	**1.486**	**.566**	**.398**	**.065**	**1.484**

* The carbohydrates include both the digestible fiber and nitrogen-free extract.

TABLE 7.

Average of Total and Digestible Nutrients Eaten Daily by Each Animal in Sheep Feeding Experiment of 1893. Estimated per 100 Pounds Live Weight. Summary.

SHEEP NUMBER.	TOTAL NUTRIENTS EATEN.					DIGESTIBLE NUTRIENTS.				
	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Fuel Value of Total Nutrients.	Protein.	Fat.	Carbohydrates*	Nutritive Ratio.	Fuel Value of Digest. Nts.
Wide Ration.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.	1:	Cal.
No. 3, -	.279	.123	1.704	.560	—	.225	.092	1.563	—	—
No. 4, -	.299	.126	1.770	.589	—	.232	.093	1.671	—	—
No. 5, -	.262	.117	1.623	.525	—	.214	.087	1.526	—	—
No. 6, -	.273	.120	1.665	.552	—	.220	.089	1.568	—	—
No. 7, -	.290	.126	1.768	.577	—	.233	.092	1.680	—	—
Average, 3-7,	**.28**	**.12**	**1.71**	**.56**	**5250**	**.22**	**.09**	**1.60**	8.2	**3760**
Narrow Rat'n.										
No. 8, -	.512	.104	1.419	.530	—	.379	.063	1.415	—	—
No. 9, -	.526	.106	1.452	.548	—	.388	.064	1.450	—	—
No. 10, -	.543	.108	1.488	.568	—	.399	.065	1.487	—	—
No. 11, -	.520	.105	1.437	.539	—	.385	.064	1.435	—	—
No. 12, -	.543	.108	1.486	.566	—	.398	.065	1.484	—	—
Average, 8-12,	**.53**	**.11**	**1.46**	**.55**	**5190**	**.39**	**.06**	**1.45**	4.1	**3680**
Stand'rd R'tns per 100 lbs. Live Weight.										
German, -	—	—	—	—	—	.30	.05	1.52	5.5	3520
American, -	—	—	—	—	—	.27	.09	1.44	6.1	3560

* Carbohydrates include both fiber and nitrogen-free extract.

RESULTS OF THE EXPERIMENTS.

At the end of the experiment March 29th, the animals were all sheared and the weight of the wool was taken. On March 30th the animals were all butchered, weighed and the meat was sent to the laboratory at Middletown for analysis.

The statistics at the time of butchering are given in table 8, on the opposite page, together with the weights at the beginning of the experiment. Animals 1 and 2 had been butchered January 5th. From the weights of the animals at the beginning and at the end of the experiment it will be seen that there was an increase in live weight, exclusive of the increase in weight due to growth of wool, varying from 14 to 31½ pounds per animal, that the average of the wide ration

group was an increase of 20.8 pounds in live weight and of the narrow ration group there was an increase of 24.3 pounds per animal. If the weights of the fleece grown during the experiment are added to the above weights, there was an average increase of 23 pounds per animal in the wide ration group and of 26½ pounds per animal in the narrow ration group.

TABLE 8.

Sheep Feeding Experiment, 1893. Statistics of Animals. All Preceding Spring Wethers.

Sheep No.	Live Weight.			Dressed Weight.	Weight of Organs, Etc.					Wool Sheared Before Taking Live Wgts.
	At beginning of Expt. Jan. 5.	At end of Expt. March 30.	Increase in 3 Months.		Lungs.	Liver.	Heart & Casing.	Kidneys.	Intestinal Fat.	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	74.0	—	—	31.0	.55	1.08	.45	.22	—	—
2	69.0	—	—	30.0	.60	1.01	.50	.20	—	—
Average,	**71.5**	—	—	**30.5**	**.58**	**1.05**	**.47**	**.21**	—	—
Fed on wide ration.										
3	66.5	85.0	18.5	42.1	.91	1.59	.56	.22	1.41	2.50
4	68.0	98.0	30.0	42.5	1.09	1.72	.56	.19	1.00	2.16
5	71.5	86.5	15.0	41.8	.94	1.28	.56	.19	1.44	2.28
6	73.0	87.0	14.0	44.2	.84	1.38	.53	.20	1.28	1.81
7	77.5	103.5	26.0	50.5	1.00	1.50	.59	.19	1.91	2.00
Avg.	**71.3**	**92.1**	**20.8**	**44.2**	**.96**	**1.49**	**.56**	**.20**	**1.41**	**2.15**
Fed on narrow ration.										
8	66.5	85.5	19.0	44.7	.75	1.38	.53	.20	1.13	2.00
9	66.0	87.5	21.5	42.5	1.00	1.56	.53	.20	.47*	1.75*
10	72.0	103.5	31.5	49.0	1.03	1.72	.59	.29	1.28	1.94
11	73.5	95.5	22.0	44.5	.94	1.53	.50	.27	1.50	2.09
12	77.5	105.0	27.5	49.8	1.19	1.69	.63	.27	1.63	2.91
Avg.	**71.1**	**95.4**	**24.3**	**46.1**	**.98**	**1.58**	**.56**	**.25**	**1.39**	**2.24**

* Omitted from averages.

The average live weight of the animals (see table 8 above) 1 and 2, which were selected for analysis at the start, was practically the same as that of the average of each of the groups (71.3 and 71.1 pounds). The average dressed weight of 1 and 2 was 30.5 pounds. The average dressed weight of the

wide ration group was 44.2 pounds and that of the narrow ration group was 46.1 pounds. If it is assumed that the animals at the start were all similar to 1 and 2, there would be an average increase of 13.7 pounds of dressed weight in the wide ration group and of 15.5 pounds in the narrow ration group.

The average weights of the lungs were practically the same in the wide ration group as in the narrow ration group, but it will be noticed that the lungs weighed nearly twice as much in the animals butchered at the end of the experiment as in those butchered at the beginning.

There was also a decided increase in the weight of the liver in both groups over that of the sheep butchered at the start. The average weight of the livers in 1 and 2 was 1.05 pounds, and in the wide and narrow ration groups 1.49 pounds and 1.58 pounds respectively.

There was also an increase in the weight of the heart and casing. The heart of 1 and 2 weighing .47 pounds and the wide and narrow ration groups each averaging .56 pounds

The weights of the kidneys in the two animals butchered at the beginning and in those of the wide ration group at the end were practically the same. In the narrow ration group there was an average increase of .05 pounds or one-fourth of the entire weight of the kidneys. One important function of the kidneys is to excrete the nitrogenous portions of the food in the form of urea and other compounds. The wide ration group had a small quantity of protein (nitrogenous substance) in the ration and hence had a small amount of nitrogen to eliminate. The narrow ration group had an excess of protein and hence much nitrogen to dispose of. In this case, as was to be expected, the organ that was called upon to perform the extra work was developed so as to adapt itself to the demands upon it.

The animals slaughtered at the beginning of the experiment had practically no fat upon the intestines. The animals of each group (with the exception of No. 9) gave an average development of about 1.4 pounds intestinal fat, there being, with the exception noted, very little difference in the averages of the two groups.

Sheep No. 9 is omitted from this average and from those of the two following tables as the results are so very different from those of the other four animals of the same group. This sheep never became reconciled to the solitary confinement

of the experiment and was always uneasy. Several times he succeeded in jumping out of the pen. To the nervous condition of the animal and his active habit, the difference found in the analytical results can doubtless be attributed. The principal difference between the composition of the flesh of No. 9 and that of the others of the narrow ration group is in the weight of fat developed, both in the flesh and in the portions of the body about the kidneys and intestines, where clear fat usually accumulates in greater or less quantity.

With the exception of sheep No. 9 there is very little difference in the growth of wool. On the whole the animals of the narrow ration group grew a little better fleece than the others did. The weights as given are for the wool as sheared and without cleansing.

TABLE 9.

Summary of Rations Fed and Averages of Digestible Nutrients Eaten and Gain in Live and Dressed Weights Per Animal.

ALL AVERAGES PER ANIMAL.	RATIONS FED.			DIGESTIBLE NUTRIENTS IN FOOD ACTUALLY EATEN.				INCREASE.	
	Grain.	Hay.	Roots.	Total Organic Matter.	Protein.	Fat.	Carbohydrates.	Live Wgt., Including Fleece.	Dressed Wgt.
Whole period of 84 days.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Wide ration, - -	108	168	126*	160.9	18.9	7.6	134.4	23.0	13.7
Narrow ration, -	108	168	—	159.5	32.7	5.0	121.8	26.5	15.6
To produce a gain of 1 lb. live weight.									
Wide ration, - -	4.7	7.3	5.5†	6.99	.82	.33	5.84	1.0	.6
Narrow ration, -	4.1	6.3	—	6.02	1.23	.19	4.60	1.0	.6
To produce a gain of 1 lb. dressed weight.									
Wide ration, - -	8.1	12.3	9.2‡	11.74	1.38	.55	9.81	1.7	1.0
Narrow ration, -	6.9	10.8	—	10.23	2.10	.32	7.81	1.7	1.0

* 36 pounds eaten. † 1.6 pounds eaten. ‡ 2.6 pounds eaten.

Table 9 above gives a summary of the grain and hay actually fed per animal in this experiment, together with the digestible nutrients actually eaten and the gain in live and dressed weights. There are also given the weights of food and

digestible nutrients which were eaten on the average per animal to produce a gain of one pound in the live and dressed weights.

CHEMICAL COMPOSITION OF THE FLESH.

As stated above, analyses were made of the flesh of the animals. In each case the right side was used for analysis. The flesh of the entire side was carefully separated from the bones and then finely cut in a sausage machine. After thoroughly mixing, a small sample was selected and prepared for analysis in the usual way.* The results of the analysis calculated both on water-free (dry matter) and fresh substance, (flesh) are given in the table (10) which follows. As explained on p. 38, sheep No. 9 is omitted from the averages.

TABLE 10.

Percentage Composition of Flesh, Edible Portion, of Animals in Sheep Feeding Experiment of 1893.

Lab. No.		Calculated on Water-free Basis.			Calculated to Water Content of Flesh.			
		Protein.	Fat.	Ash.	Water.	Protein.	Fat.	Ash.
	At Beginning of Exp't.	%	%	%	%	%	%	%
364	Sheep No. 1, - -	44.50	52.90	2.60	59.95	17.83	21.18	1.04
365	Sheep No. 2, - -	38.27	59.40	2.33	56.77	16.54	25.68	1.01
	Average 1 and 2, -	**41.39**	**56.15**	**2.46**	**58.36**	**17.19**	**23.43**	**1.02**
	Wide Ration.							
366	Sheep No. 3, - -	38.20	59.66	2.14	58.13	16.00	24.97	.90
368	Sheep No. 4, - -	35.97	62.06	1.97	58.07	15.07	26.03	.83
370	Sheep No. 5, - -	36.22	61.79	1.99	58.24	15.13	25.81	.82
372	Sheep No. 6, - -	32.15	66.12	1.73	57.23	13.75	28.28	.74
374	Sheep No. 7, - -	32.03	66.26	1.71	55.07	14.39	29.77	.77
	Average 3–7, - -	**34.91**	**63.18**	**1.91**	**57.35**	**14.87**	**26.97**	**.81**
	Narrow Ration.							
367	Sheep No. 8, - -	34.31	63.89	1.80	56.35	14.96	27.91	.78
369	Sheep No. 9,† - -	53.84	43.33	2.83	68.27	17.08	13.76	.89
371	Sheep No. 10, - -	38.63	59.29	2.08	59.63	15.59	23.94	.84
373	Sheep No. 11, - -	38.54	59.38	2.08	61.18	14.96	23.05	.81
375	Sheep No. 12, - -	34.65	63.55	1.80	58.21	14.50	26.55	.74
	Average 8, 10–12 (4),	**36.54**	**61.52**	**1.94**	**58.84**	**15.00**	**25.37**	**.79**

† Omitted from averages.

In table 11 there are given the weights of the nutrients, etc., in the flesh of each animal of the experiment. The figures in the last five columns were obtained by multiplying the weight of flesh (edible portion) by the percentage composition of the

* For methods of analysis of meats, see Report of this Station for 1891, pp. 47–49.

animals as given in table 10. Sheep No. 9 was omitted from the averages for reasons given on page 38.

TABLE 11.

Weights of Flesh, Refuse, and Nutrients in Flesh of Animals in Sheep Feeding Experiment of 1893.

	Live Weight.	Dressed W'g't, without Kidneys & Hoofs.	Refuse (Bone).	Edible Portion (Flesh).	In Edible Portion (Flesh).				
					Water.	Water-free Substance.	Water-free Sub.		
							Protein.	Fat.	Ash.
Beginning of Exp't.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Sheep No. 1, -	74.0	29.49	6.36	23.13	13.85	9.28	4.14	4.90	.24
Sheep No. 2, -	69.0	28.80	5.41	23.39	13.27	10.12	3.87	6.01	.24
Av. 1 and 2, -	**71.5**	**29.15**	**5.89**	**23.26**	**13.56**	**9.70**	**4.01**	5.45	**.24**
Wide Ration.									
Sheep No. 3, -	85.0	40.99	7.07	33.92	19.72	14.20	5.43	8.47	.30
Sheep No. 4, -	98.5	41.25	8.99	32.26	18.74	13.52	4.86	8.39	.27
Sheep No. 5, -	86.5	40.55	7.63	32.92	19.18	13.74	4.97	8.50	.27
Sheep No. 6, -	87.0	43.08	6.31	36.77	21.04	15.73	5.06	10.40	.27
Sheep No. 7, -	103.5	48.96	7.74	41.22	22.69	18.53	5.93	12.28	.32
Av. 3–7, -	**92.1**	**42.97**	**7.55**	**35.42**	**20.28**	**15.14**	**5.25**	**9.60**	**.29**
Narrow Ration.									
Sheep No. 8, -	85.5	43.73	7.04	36.69	20.66	16.03	5.50	10.24	.29
Sheep No. 9,* -	87.5	41.29	7.85	33.44	22.82	10.62	5.72	4.60	.30
Sheep No. 10, -	103.5	47.72	8.16	39.56	23.59	15.97	6.17	9.47	.33
Sheep No. 11, -	95.5	43.01	8.69	34.32	21.00	13.32	5.12	7.92	.28
Sheep No. 12, -	105.0	48.32	8.35	39.97	23.27	16.70	5.79	10.61	.30
Av. 8, 10–12, -	**97.4**	**45.70**	**8.06**	**37.64**	**22.13**	**15.51**	**5.65**	**9.56**	**.30**

* Omitted from average.

The following table points out the difference in the composition of the flesh:

Changes in Composition of Flesh, with Different Rations. (Increase, +. Decrease, —).

	In 100 lbs. Water-free Substance of Flesh.			In 100 lbs. of Flesh.			
	Protein.	Fat.	Ash.	Wa	Protein.	Fat.	Ash.
Increase over beginning of Experiment.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Wide ration, - - -	—6.4	+7.0	—0.6	—1.0	—2.3	+3.5	—0.2
Narrow ration, - -	—4.8	+5.4	—0.6	+0.5	—2.2	+1.9	—0.2
Increase of narrow over wide ration, - -	+1.6	—1.6	+0.0	+1.5	+0.1	—1.6	+0.0

In the dry matter (water-free substance) of flesh there was in each group an increase in the fat and a corresponding decrease in protein and ash. These differences were greater in the wide ration group, as the last line of the table points out.

The chief differences in composition between the different groups when calculated to fresh substance of flesh, are still due to the fat. One of the facts brought out very early in our study of the composition of animal foods was that water and fat to a very great extent replace each other. This is strikingly shown in the composition of the flesh of the animals of the wide and narrow rations. The protein is nearly the same in each, while the flesh of the narrow ration animals contains 1.5 pounds per 100 more water, and 1.6 pounds per 100 less fat than that of the wide ration group.

The average differences in composition are pointed out in the following table:

Changes in Weights of Nutrients, with Different Rations.

	Edible Portion (Flesh).	In Edible Portion (Flesh).				
		Water.	Water-free substance.	In Water-free Substance.		
				Protein.	Fat.	Ash.
Increase over beginning of Exp't.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Wide ration group, average of 5 animals, - - - - -	12.12	6.72	5.44	1.24	4.15	.05
Narrow ration group, average of 4 animals, - - - - -	14.38	8.57	5.81	1.64	4.11	.06
Increase of narrow ration over wide ration group, - - - -	2.22	1.85	.37	.40	−.04	.01

The gain in the weight of flesh was enough greater in the animals of the narrow ration group to very nearly compensate for the lower percentage of fat, so that the weight of fat was nearly as great in this group as in the wide ration group. The increase in dry matter, water and protein was to have been expected from the percentage composition.

The work is being continued during the present winter (1893–4) and practical conclusions are reserved.

Expt. Sta. Conn. Rep.
1894: 77-91.

BACTERIA IN THE DAIRY.*

See also Bul; 2

BY H. W. CONN.

V. THE RIPENING OF CREAM BY ARTIFICIAL CULTURES OF BACTERIA.

Experiments upon artificial ripening of cream are not new. It was Professor Storch of Copenhagen (*Milchzeitung*, 1890, p. 304) who first called attention of bacteriologists to the subject by using artificial cultures of bacteria for the purpose and showing that while some species produced an excellent aroma in the butter, others produced butter of very inferior quality. Others have followed this lead, especially Weigmann (*Landw. Woch. Schleswig-Holstein*, 1890, pp. 551 and 869) and Adametz and Wilckens (*Landw. Jahrb.*, 1892, p. 131) and artificial cultures for this purpose have for some time been furnished to creameries in Europe and to a slight extent in this country. The exact effect upon butter of the numerous species of bacteria which are liable to occur in cream is too little known from these experiments. Storch and Weigmann were endeavoring to find a proper species for the purpose and have given us too few details concerning other species. Adametz and Wilckens gave more detailed accounts of several species but there is still little known of the effect of the great bulk of milk bacteria.

In this country very little knowledge of these general facts is found among dairymen. For the purpose of giving a wide information upon the subject, the Office of Experiment Stations at Washington requested me to prepare an exhibit illustrating some of these facts for the Columbian Exposition. In preparing for this exhibition a large number of experiments have been performed upon the ripening of cream by the aid of artificial cultures of different species of bacteria. These experiments are somewhat novel in their character and unlike any that have been

*During the past six years investigations on the Bacteria of Milk have been conducted in behalf of the Station by H. W. Conn, Professor of Biology in Wesleyan University. Some of the results have been given in the publications of the Station, as follows: *Bacteria in Milk, Cream, and Butter*, Bulletin 4, and Annual Report for 1889, pp. 52–67. *Ripening of Cream*, Annual Report for 1890, pp. 136–157. *A Micrococcus of Bitter Milk*, Report for 1891, pp. 158-162. *The Isolation of Rennet from Bacteria Cultures*, Report for 1892, pp. 106–126. See also *The Fermentations of Milk*, Experiment Station Bulletin No. 9 of the Office of the Experiment Station of the U. S. Department of Agriculture.

as yet carried on in any bacteriological laboratory. The results, while aimed especially at preparing a proper exhibit for the Columbian Fair, have, at the same time, been of great interest to the practice of butter making, both scientifically and practically. For this reason it is thought well to give at the present time the methods of these experiments and the general summary of the results, especially as they add considerably to our knowledge of the relation of different species of organisms to the matter of butter making.

The first object of the experiments was to find certain species of bacteria whose use in the ripening of cream would produce a marked effect upon the aroma of the butter. It was desired to obtain one or more species whose agency would produce a pleasantly flavored butter, and one or more whose agency, under identical conditions, would produce an unpleasantly flavored butter. For this purpose I have experimented with a large number of species of bacteria. The species used in the experiments were mostly obtained from ripened cream. Visits were made to the Cromwell creamery, the Ellington creamery, and the Wapping creamery in this State. From the vats of ripened cream ready for churning which were found in the creameries at the time of the visit, an inoculation was made into gelatine, roll cultures made therefrom immediately, and these roll cultures were brought home and left in the laboratory for the bacteria to develop. At the end of two or three days the roll cultures showed the presence of numerous bacteria, and the organisms of the different colonies were isolated from the cultures in the ordinary manner. The species of bacteria were then put through a series of plate cultures in order to purify them, and lastly, carried through a series of cultures in various media for the purpose of determining their specific characters. The species thus obtained were numbered, inoculated into agar tubes and kept for further experiment. In addition to the bacteria thus obtained a few species were used which had been isolated from the water of a brook in this vicinity. The reason for this additional source for bacteria cultures is found in the fact that most of the species of bacteria isolated from the cream failed to produce as striking effects upon the butter as was desired for the exhibit of the Columbian Fair, and it was thought that organisms of a different sort might be made valuable for this purpose. The species finally chosen for demonstration at Chicago were, however, all obtained from cream.

Having thus obtained a number of species of bacteria, between thirty and forty in all, the experiments with ripening cream were performed as follows:* Four quarts of milk were obtained daily from a milk dealer and the milk was passed through the centrifugal machine. The cream obtained each day was about one pint. It was divided at once into two lots of half a pint each and each lot placed in a sterilized fruit can. The cream was now put into a pail of water and the water heated by steam until the temperature of the cream reached 69° or 70°C. (158°F.) This temperature was continued for five or ten minutes and then the cream, closed from the air, was set aside to cool, or cooled under the water tap. After cooling it was ready for inoculation and ripening.

In heating the cream up to the temperature of 70°C. (158°F.) as above explained, it was not expected that the cream was sterilized. On the contrary it is well known from many experiments, that such a temperature leaves many bacteria in the cream, especially in the form of spores. Nevertheless, this method, which is generally known as pasteurization, does so reduce the number of bacteria that it was thought to be satisfactory for purposes of our experiment. There would be left in the milk some spores which would germinate somewhat slowly, but only a small number of active bacteria would be present. It was assumed that if to such cream a sufficient quantity of the bacteria of experiment was added in culture, these bacteria being present in such quantities in the cream, would grow rapidly and produce their own effect upon the cream, independent, or nearly independent, of the normal species that chanced to remain after the sterilization. It is, of course, understood that the experiment would be more rigidly correct if the cream could have been sterilized. That, however, was an impossibility, because sterilization, requiring a temperature of at least 100°, also produces in the cream the taste of boiled milk, and that taste is carried over into the butter and produces a flavor in the butter entirely foreign to normal butter. In one or two experiments of this sort that were performed, the taste of the boiled milk was so much more prominent than any other flavor, that the influence of the bacteria of the experiment was entirely obliterated (see experiment 74). The only other method of absolutely sterilizing the cream would have been to

* These experiments were carried out by Mr. William M. Esten, who also had charge of the exhibit at the Columbian Exposition.

heat it to 70° for five or six days in succession, and this process is so long and tedious that it was found to be practically impossible under the conditions of the experiment. Moreover, as the experiments continued, it became evident that the expectation that pasteurization so far destroyed bacteria as to render the experiments successful, was plainly realized. Tests were frequently made by comparing the pasteurized cream without inoculation, with pasteurized cream after inoculation, both lots being ripened for the same length of time at the same temperature. In all such experiments it was found that the uninoculated pasteurized cream was practically unripened at the end of the experiment, while the inoculated cream showed a very marked ripening, due to the bacteria inoculated. This was true only when moderate temperatures were used. At a temperature of 35°C. (95°F.) the pasteurized cream became over-ripened. Moreover, it was found that the experiments in general were uniform in their results. The same species of bacteria inoculated into the pasteurized cream gave, in all cases, under similar conditions, the same results. This, of course, would not have been expected had the few bacteria which chanced to be left in the sterilized cream had any marked effect. As will be seen later some irregularities were probably due to this unavoidable error. The control experiments which were occasionally performed in this way, gave us evidence enough that the method adopted, while not rigidly exact, was sufficiently exact for proper conclusions to be drawn as to the effect of special species. In one experiment, cream was inoculated with No. 27, was then pasteurized and inoculated with No. 18 and ripened. The resulting cream and butter were such as is produced by No. 18 and no trace of No. 27 was seen. Moreover, it must be recognized that if artificial inoculation of cream ever becomes possible in butter making, it will probably never be possible for butter makers absolutely to sterilize their cream. The high temperature required for this, rendering the butter worthless because of its boiled milk taste. Pasteurizing cream at 70° C. (158°F.) may be a practical possibility, though this may be questioned, and for this reason, in addition to those above given, this method of pasteurization was regarded in our experiments as preferable to any attempt at thorough sterilization of the cream. The chance of error, however, made it necessary to repeat experiments many times until uniformity was obtained.

The cultures used for ripening were made as follows: Skimmed milk was placed either in large test tubes or in Erlenmeyer flasks and sterilized by steam on four or five successive days, an absolute sterilization being thus obtained. The amount of the milk in each flask was varied in the different experiments for the purpose of determining the most convenient quantity to use. It was found as the result of many experiments that the best quantity was about one-thirtieth of the amount of cream to be inoculated, bulk for bulk. After sterilization the milk was inoculated with a loop full of a pure culture of the organisms to be tested, obtained from agar tubes. The inoculated milk was then allowed to grow for a varying length of time at varying temperatures, the variations in time and temperature being for the purpose of determining the best conditions under which the growth should occur. There were thus obtained milk cultures of the species to be experimented upon whose age was from one to fourteen days or more. A culture of about two days was found to be most satisfactory.

The cream ripening was conducted as follows: After the pasteurization of the cream as above described, it was cooled to a temperature of 30° C. (86°F.) or lower, and the milk culture was poured into it. The milk can was then closed to prevent the entrance of dust, either by closing the can with its proper cover, or by filling it with a plug of cotton, and the cream was set aside to ripen. In the various experiments the ripening was carried on at three different temperatures, the temperatures chosen being 37°, 27°, and 20°C. (99°, 81° and 68°F.) The experiments also varied as to the length of the ripening, in some cases the ripening being allowed to continue for twenty-four hours at the above mentioned temperatures, and at others for forty-eight hours. During the ripening the cream was occasionally shaken to produce as thorough contact with oxygen as possible and thus to imitate closely the conditions in the vat of the ordinary creamery.

The temperatures used in ripening are all higher than those usually used in creameries. But this was found to be advantageous in our work. The cream could be ripened for forty-eight hours at 20°C. (68°F.) and not be over-ripened, and even the temperature of 27°C. (81°F.) did not injure the cream in twenty-four hours ripening. Such temperatures would have over-ripened cream as ordinarily collected for creameries. The probable explanation is as follows: 1. Our cream was probably not as highly inoculated with bacteria

as normal cream, and a longer time would therefore be required for bacteria growth. 2. Our cream continued a nearly pure culture, and the changes in the cream would be less rapid than when several species were working together. As is well known, a bacteria culture increases most rapidly in the first period of its growth. Later the growth is greatly checked. For this reason, cream would more slowly be changed by a single growing species than by several growing together, even though at first the actual number of individuals was the same. In a few experiments with combined cultures it was found that the ripening was more rapid than with an equal quantity of a pure culture. These facts explain the result which may appear so strange to a butter maker, that cream has been ripened forty-eight hours at 20°C. (68° F.) and then found to be under-ripened and too mild.

After the ripening had continued the proper length of time for the experiment, the cream was tested as to its acid or alkaline reaction. Note was made as to whether bubbles of gas had been produced during the ripening, as to whether the cream had noticeably thickened or not, and very careful note was taken of the odor and the taste of the ripened cream. The cream was then cooled to a temperature of 14½ degrees C. (58°F.) and was then churned. For churning we used an ordinary milk-shaking machine, such as is used by druggists for shaking liquids. The fruit can, about half full of cream, was placed in the shaker and the churning occupied only a very short time, varying from one to ten or twelve minutes, according to conditions, and according to the different species of bacteria that had been used in ripening. After churning, the butter was washed once or twice in water at a temperature of 15°C. (59° F.), and was then worked between butter ladles so as to remove the excess of buttermilk and to imitate as closely as possible the ordinary method of butter working. In some of the experiments salt was added to the butter in the proportion of one to sixteen. In other experiments the butter was worked without salting. It was found that is was preferable not to salt the butter before testing, inasmuch as the salting more or less disguised the flavor produced by the ripening, and in these experiments, in some of which the aroma was quite delicate, it was desirable to have the flavor given to the butter as prominent as possible. It was found that those to whom the butter was submitted for tasting could very much more readily determine the flavor of the butter without the previous

addition of salt, although, in many experiments the flavor was so marked that the addition of salt gave no particular trouble. Salting disguises many a bad-flavored specimen of butter so as to make it passable.

After the butter was thus worked, it was submitted to a number of persons for judgment. In no case did the persons tasting the butter in this way have any knowledge of the particular condition under which the experiments had been made, and did not know, therefore, whether to expect pleasantly or unpleasantly flavored butter. In the verdict given in regard to the butter in the different experiments, there was considerable variation, on the part of different persons, as was to be expected. A butter which one individual would declare excellent, another would regard as only passable, and some persons preferred butter which other persons called strong and rank-flavored. This was anticipated before the experiments began, because, as is well known, the public taste for butter is a very variable one, and it was not to be expected that the delicate shades of difference between differently flavored butters would affect all persons in the same way. Nevertheless, in spite of these differences, there was quite a general consensus of opinion, and all of the marked variations were noticed by all of the persons to whom the specimens were submitted.

These experiments were nearly always carried on in pairs. Sometimes the same species would be used for ripening in each of the pair, but at different temperatures. At other times the same species would be used at the same temperature, but for different periods of ripening. At other times the same species was used at the same temperature, with different periods of ripening, but with a longer period of preliminary growth of the culture in sterilized milk. Sometimes different species were used under identical conditions. Sometimes a can of sterilized cream, uninoculated, would be carried through the ripening process side by side with one inoculated, to compare the ordinary experiments with the effect of no addition of bacteria. In general, the attempt was made, as far as possible, to determine the effect of the different species upon the ripening at different conditions, and to make the experiments as strictly comparable with each other as possible.

The following is the description of the specific characters of the organisms used in the experiments:

No. 2.

Locality.—Found in milk in Middletown, October, 1892, and also in ripened cream in Ellington Creamery, November, 1892.

Morphology.—A micrococcus, size 1 μ. to 1.2 μ. It never forms chains. Grows the same on potato and agar.

Motility.—No motion.

Relation to Air.—Growth under mica, none, or very slight.

Colony on Gelatine.—A slight pit appears, which begins to liquefy. The colony at this time is smooth and uniform. As it grows it breaks up, resulting in a liquid colony with a somewhat clear center, which may contain few granules, and a periferal ring with dense granules. Sometimes the ring is not at the edge and is very dense and distinct.

Gelatine Stab Culture.—Liquefies into a shallow pit with a thick granular yellowish scum. Liquefies slowly, only a quarter of an inch of the gelatine being liquefied after several weeks.

Agar-Agar.—A dry, raised, discreet streak of a salmon or Naples yellow color. Surface is wrinkled, rather tenacious and sticky.

Potato.—A thick, dry mass, which occasionally spreads slightly or sometimes forms a series of distinct beads. Rough and wrinkled. Color varies from white flesh color to a decided brown. Frequently salmon color.

Temperature.—Grows equally well at 20° and 35°. Color not so well developed at 35°.

Milk.—At 20° or at 35° milk is coagulated. Coagulum rather hard with little whey. Orange masses on top. Odor, sour. Alkaline reaction, at least at first. No digestion of the casein occurs. Chemical analysis shows the presence of butyric acid and alcohol.

Bouillon.—Liquid clear, with a slight precipitation and no scum. Later, liquid becomes cloudy and a slight scum forms.

Two varieties of this organism have been found, differing in the brilliancy of the pigment only.

No. 5.

Locality.—Ripened cream from Cromwell creamery, October, 1892.

Morphology.—A large rod 2 μ. by 1 μ., never forming chains. On agar it is somewhat smaller than on gelatine. No spores observed, occasionally a tendency toward a bi-polar stain noted.

Motility.—

Temperature.—Growth slight at 35°, and green color not produced.

Relation to Air.—Will not grow under mica.

Colony on Gelatine.—A white colony which sinks into a pit with a granular center and a clear rim, spreading into a round, uniformly granular circle with a radiating rim and a greenish tinge.

Gelatine Stab.—Liquefies slowly into a broad funnel, with a thick, tenacious scum. Liquid green and later yellow.

Agar-Agar.—Smooth, moist, rough growth which becomes abundant after a few days and is very sticky. Agar turned green.

Potato.—An abundant white growth with yellowish tinge spreading over the surface of the potato. Smooth and glistening. Sometimes it forms mounds, sometimes a rough, folded mass with pits.

Milk.—Does not curdle at 20°, but turns slowly brownish. At a higher temperature it may form a soft curd with a cloudy whey. Reaction amphoteric or alkaline. Is slowly digested into a lemon yellow, cloudy liquid.

Bouillon.—Uniformly cloudy with abundant sediment. Liquid green.

Nos. 16 and 16*i*.

The two varieties named, 16 and 16*i*, resemble each other very closely in their specific characteristics. It was found impossible to distinguish between them, except by their effect upon butter. In all the experiments 16*i* produced butter which was decidedly sour, while the butter produced by 16 was less sour and was usually regarded as excellent. The characteristics are as follows:

Locality.—Ripened cream from Mansfield, October, 1892.

Morphology.—An oval rod or micrococcus about 1 μ. in length.

Motility.—Stationary.

Relation to Air.—Grows well under mica.

Temperature.—Grows profusely at 35° as well as at 20°.

Colony on Gelatine.—Forms first a white bead, which spreads rapidly over the surface and is slightly iridescent. Sometimes forms a lobular colony with a raised central nucleus; sometimes there is an outer clear, transparent rim with a raised center. In six days colony reaches dimensions of 2 mm.

Gelatine Stab.—An abundant needle growth with a raised, round, smooth surface growth. Gas frequently produced in gelatine.

Agar-Agar.—A diffused, white, shining growth. Sometimes quite thin, at other times thick with a sharp edge.

Potato.—Very abundant, thick and spreading, white with an irregular surface.

Milk.—Curdles at 35°. Surface with a clear whey, which becomes fragmented and full of bubbles. Does not curdle at 20°. Is strongly acid and shows no digestion.

Bouillon.—Produces a uniformly cloudy liquid with a sediment and a slight scum round the edges of the tube.

No. 18.

Locality.—Mansfield, October, 1892.

Morphology.—A bacillus 2 μ. by 1.4 μ. Occasionally two or three may be seen attached together. Produces spores in its potato growth. Growth on agar the same, though slightly larger.

Motility.—No motion.

Relation to Air.—Grows under mica.

Temperature.—Grows profusely at 35° and at 20°.

Colony on Gelatine.—A white bead which spreads slightly and forms a round, smooth, glistening colony, about 1 mm. in diameter.

Gelatine Stab.—Abundant growth along the needle track. A white nail growth on the surface which spreads in a rather dry layer.

Agar-Agar.—A white, scanty, narrow streak along inoculation line. Sometimes spreads. Not very characteristic.

Potato.—Spreads abundantly into a thick, white, diffused, mottled layer, sometimes raised into mounds. Later it turns decidedly brown and more uniform.

Bouillon.—Produces a uniformly cloudy liquid with a sediment. A slight scum appears after several days.

Milk.—Is curdled slowly at 35°, and becomes acid. At 20° no effect on milk is seen.

NO. 19.

Locality.—Cromwell, October, 1892.

Morphology.—A short rod 2 μ. by 1 μ. with rounded ends. It never forms chains, has uniform stain and shows no spores.

Motility.—

Relation to Air.—Will not grow under mica.

Temperature.—Will not grow at 35°.

Colony on Gelatine.—A smooth, round surface colony with slow growth, which becomes after six days a lemon yellow colony about ½ mm. in diameter and sinks into a liquefying pit.

Gelatine Stab.—Slight needle growth. A thin, opaque surface of a lemon yellow color, which becomes sunken in the middle into a pit. After a week the pit is quite deep, but the gelatine does not liquefy.

Agar-Agar.—An abundant, smooth, spreading, lemon yellow growth.

Potato.—An abundant, moist, lemon yellow growth.

Bouillon.—A uniformly slightly cloudy liquid with a very slight sediment.

Milk.—Is rendered slightly alkaline, but is not curdled. After two weeks' growth at 20° the milk becomes partly transparent, showing that its casein has been peptonized. In six weeks milk becomes completely transparent and of a dark brown, almost red color.

NO. 20.

Locality.—Cromwell creamery, October, 1892.

Morphology.—A small bacillus 1–3 μ. by .7 μ. A uniform stain. No spores seen. Occasionally adhere in chains of three or four.

Motility.—

Relation to Air.—Will grow under mica.

Temperature.—Grows well at 35° and 20°.

Colony on Gelatine.—A white bead spreading into a round surface colony 1 mm. in diameter, sunken in the middle with a raised rim around the edge.

Gelatine Stab.—Gas produced; slight needle growth and slight, dry surface growth.

Agar-Agar.—Spreads diffusely in a thin, white layer showing branching marks radiating from the central streak.

Potato.—Spreads diffusely into a watery mass with a yellow tinge. Later the growth thickens and the color may become a darker olive.

Milk.—Curdles at 37°, but not at 20°. When curdled it is acid.

Bouillon.—A uniformly cloudy liquid with a sediment. After three weeks a rather tenacious white scum appears.

NO. 21.

Locality.—Ellington creamery, November, 1892.

Morphology.—A slender rod 2 μ. by .8 μ. Frequently associated in long chains. No spores seen.

Motility.—Is motile.

Relation to Air.—Will not grow under mica.

Temperature.—Grows well at 35°, though not so well as at 20°. Green color is not formed at 35°.

Colony on Gelatine.—A small, opaque colony which rapidly liquefies into a large, greenish, slightly granular colony. When liquefying, at first the granular mass is associated at the center in a nucleus, but subsequently diffused throughout the liquid.

Gelatine Stab.—Growth is slow. A shallow pit is formed, which becomes a deep, broad funnel. Later there is formed a liquid layer with a scum and a precipitate, and a clear, green liquid between.

Agar-Agar. — Thin, white, almost transparent, moist growth, spreading slightly. Agar becomes greenish.

Potato.—Diffusely spreading, forming a thin, moist, brownish layer.

Milk.—Curdles at 20° and also at 35°. Reaction is alkaline, casein becomes digested slowly.

Bouillon.—A uniformly cloudy liquid with a slight scum. An abundant sediment forms in six days. Liquid very cloudy toward the surface and slightly green. Later a very tenacious scum forms on the surface.

NO. 22.

Locality.—Ellington creamery, November, 1892.

Morphology.—A short, oval rod about 1.2 μ.—2 μ. by 1 μ. Variable in size. No spores. Stain uniform.

Motility.—Stationary.

Relation to Air.—Will not grow under mica.

Temperature.—Very slight growth at 35°.

Colony on Gelatine.—A rather thick, spreading colony formed with a central nucleus and a transparent edge, which shows radiant lines.

Gelatine Stab.—Abundant needle growth. A thick, dirty white, opaque surface growth, which later sinks slightly in the gelatine.

Agar-Agar.—A dry, opaque layer with transparent edges. Spreads slightly.

Potato.—A white, narrow, raised streak, which later becomes yellowish.

Milk.—No curdling. Reaction alkaline. Milk becomes slightly translucent.

Bouillon.—Liquid uniformly cloudy, with no scum and only a slight precipitate.

NO. 23.

Locality.—Ellington creamery, November, 1892.

Morphology.—A plump rod nearly as long as broad, 1.5 μ. by .8 μ. Sometimes two will be seen, but no chains. Spores numerous. On potato it forms longer rods, 5 μ. in length.

Motility.—Is motile.

Relation to Air.—Grows under mica, producing gas bubbles.

Temperature.—Grows well at 20° and 35°.

Colony on Gelatine.—A small, round, clear, transparent colony, forming a white bead on the surface half a millimeter in diameter. In five days it reaches the diameter of one millimeter and is a small, round, glistening, white colony.

Gelatine Stab.—A thin, rough, almost transparent surface growth.

Agar-Agar.—A white, moderately thick, spreading layer.

Potato.—An abundant white growth, glistening and moist, thick and heaped in mounds. Later distinctly brown.

Milk.—Thickens into a pasty mass, but does not curdle at any temperature. Turns slightly brown after a week or more. Reaction is acid.

Bouillon.—A cloudy liquid with no scum, but an abundant precipitate.

NO. 25.

Locality.—Ellington creamery, November, 1892.

Morphology.—A bacillus 2 μ. by .7 μ. Uniform stain, no chains, producing spores.

Motillty.—Is motile.

Relation to Air.—Grows well under mica.

Temperature.—Grows well at 35°.

Colony on Gelatine.—Minute, round, clear colony, raised into a bead showing concentric wrinkles. May spread to a diameter of one millimeter with a central nucleus and a darker, broader rim, separated by a partly clear space. The rim may be rough and lobed.

Gelatine Stab.—Abundant needle growth, which is rough and beaded. Slight nail growth on surface spreading widely into a thin, transparent, dry layer, which later becomes quite white.

Agar-Agar.—White, moderately thick growth, not characteristic.

Potato.—A grayish, dry, raised mass, which becomes yellowish and spreads where potato is moist. Color from yellow to a brown ochre.

Milk.—Rendered slightly alkaline, otherwise not changed.

Bouillon.—Uniformly cloudy. A slight sediment which becomes very abundant. After three weeks a scum forms as tenacious white flakes.

NO. 26.

Locality.—Ellington, November, 1892.

Morphology.—A slender rod 4 μ. by 1 μ. Size variable. Frequently forms long chains. Bi-polar stain noticed. No spores.

Motility.—Non-motile.

Colony on Gelatine.—A rosette shaped colony with a central dark nucleus and granular rays. Sometimes a double rosette, one round the nucleus and another outside. Rosette lobing may be very coarse or very fine and delicate or sometimes simply granular on the edge.

Gelatine Stab.—A moderate needle growth. A thin, rough, transparent surface dotted with opaque spots.

Agar-Agar.—A very white, moderately thick growth.

Potato.—Gray white, slightly spreading growth with occasionally a faint tinge of yellow.

Milk.—Is not curdled at any temperature. Becomes alkaline. At 20° it becomes slightly transparent in a few days, and after six to eight weeks is converted into a pasty brown, semi-translucent mass with a strong alkaline reaction.

Bouillon.—Uniformly clear liquid. After six days a slight sediment appears. In eight days liquid becomes cloudy and later still a scum forms on the surface which is iridescent and sinks in flakes on being disturbed.

NO. 27.

Locality.—Ellington, November, 1892.

Morphology.—A short rod 1.3 μ.—2 μ. by .8 μ. Uniform stain. No spores. No chains.

Motility.—Is motile.

Relation to Air.—Grows under mica.

Temperature.—Grows well at 20° and 35°.

Colony on Gelatine.—Clear, transparent colony under the surface, spreading on the surface into a clear, transparent, mounded colony with wrinkled edges.

Gelatine Stab.—Abundant needle growth, beaded. Slight surface growth at first, later spreading into a thin, transparent surface layer.

Agar-Agar.—White, raised growth, not characteristic.

Potato.—Narrow, raised streak, with a yellowish tinge, spreading where moist.

Milk.—Does not curdle. Is rendered alkaline and acquires a disagreeable odor and a bitter taste. After several weeks digested into a brownish liquid.

Bouillon.—Cloudy with a scum and an abundant precipitate.

No. 31.

Locality.—Water from a brook, January, 1893.

Morphology.—A bacillus frequently forming long chains. Uniform stain and no spores. Dimensions 1.5 μ. by .9 μ.

Motility.—

Relation to Air.—No growth under mica.

Temperature.—No growth at 35°.

Colony on Gelatine.—Small, round colony with radiating marks under the surface of the gelatine. On the surface a raised bead which becomes surrounded by a clear, granular pit. Granular central mass gradually breaking up and dispersing in the pit.

Gelatine Stab.—Liquefies slowly into a deep funnel, filled with green liquid.

Agar-Agar.—White, smooth, moist, glistening growth, rather diffuse. Agar turned green.

Potato.—Gray and dry, later becomes brownish. Quite thick.

Milk.—Becomes slimy at 20°. Is strongly alkaline. Digestion of casein begins at once and milk rapidly becomes a yellowish green liquid completely digested.

Bouillon.—Cloudy liquid with thick scum. Green one-half inch from top. A sediment collects. After ten days is green throughout and with very thick scum.

With the above described organisms a large number of experiments in cream ripening have been performed, over 150 in all. About two-thirds of them are given in detail in the following table (12). The other experiments either agreed with those described and were for this reason unnecessary, or were omitted since they were isolated and too few to lead to reliable conclusions. The table represents experiments extending from November to April, which were all performed with organisms isolated from cream or water in the months of October or November.

TABLE 12.

Exp't. No.	Temperature and Time of Ripening.	Age of Culture.	Appearance of Ripened Cream.	Reaction of Ripened Cream.	Odor of Ripened Cream.	Taste of Ripened Cream.	Butter.
			Organism No. 2.				
1	20° 1 d.	4	- - - - - -	Neutral, -	- - - -	- - - - -	Good flavor, not enough flavor for first-class.
2	20° 1 d.	5	Not thickened, - -	Neutral, -	Slightly unpleasant,	- - - - -	Good, but mild.
3	25° 1 d.	1	Slightly thickened, -	Alkaline, -	Slight, unpleasant, -	Prominent, but pl's'nt,	Not churned.
4	25° 1 d.	5	Slightly thickened, -	Alkaline, -	Sweet, - - -	Sweet, - - -	Excellent, first-class.
5	25° 1 d.	4	Slightly thickened, -	Alkaline, -	Sweet, - - -	Prominent, sweet, -	Excellent.
6	25° 1 d.	2	Slightly thickened, -	Alkaline, -	Slightly musty, pl's'nt,	Sweet, quite strong, -	Finely flavored.
7	28° 1 d.	5	Very slightly thickened, -	Alkaline, -	Sweet, - - -	Sweet, - - -	Excellent flavor, though not very strong.
8	28° 1 d.	4	- - - - - -	Neutral, -	Sweet, - - -	Sweet, - - -	Excellent flavor, but mild.
9	28° 1 d.	—	Slightly thickened, -	Alkaline, -	Very slight but sweet,	Sweet, - - -	Mild though good flavored.
10	28° 1 d.	7	Slightly thickened, -	- - -	Pleasant, - -	- - - - -	Good, but too strong. Over ripened.
11	28° 1 d.	2	Slightly thickened, -	Neutral, -	Slightly curdy, faint,	Pleasant, aromatic, -	First-class.
12	28° 1 d.	1	- - - - - -	Neutral, -	Slight, - - -	Sweet, - - -	Good, but not first-class.
13	20° 2 d.	4	Little changed, - -	Alkaline, -	Slight, - - -	Sweet, pleasant, -	Very good flavor.
14	20° 2 d.	1	Little changed, - -	Alkaline, -	Slight, - - -	Sweet, - - -	Good, but mild.
15	20° 1 d. / 37° 2 h.	—	Little changed, - -	Neutral, -	Slight, - - -	Very little, - -	Mild, slight burning taste.
16	20° 1 d. / 37° 3 h.	—	Little changed, - -	Alkaline, -	Unpleasant, - -	Slight, - - -	Good flavor, but too mild.
17	25° 2 d.	4	Little changed, - -	Neutral, -	Slight, musty, - -	Sweet, - - -	Good flavor, but too mild.
			Organism No. 22.				
18	25° 1 d.	12	Slightly thickened, -	Alkaline, -	Sweet, - - -	Sweet, - - -	Excellent flavor, but mild.
19	25° 1 d.	2	Scarcely altered, - -	Alkaline, -	Slight, - - -	Sweet, - - -	Good, mild.

20	25°	1 d.	4	Scarcely altered,	Alkaline,	- - - -	Sweet, pronounced,	Mild, stronger than Expt. 19.
22	28°	1 d.	22	Full of bubbles,	Alkaline,	Musty and sickish,	Musty, sweet, pleasant,	Very mild, good flavor, but peculiar.
23	28°	1 d.	21	- - - - -	Neutral,	Slight, unpleasant,	Sweet,	Not good.
24	28°	1 d.	8	Not altered,	Alkaline,	Pleasant,	Sweet,	Sticky, full of slime, good flavor.
25	35°	1 d.	2	C'rdl'd, hard, full of bubbles,	- - -	- - - -	- - - -	Worthless.
26	35°	1 d.	14	Over-ripened, worthless,	- - -	- - - -	- - - -	Very bad.
27	28°	1 d.	4	Slightly thickened,	Acid,	Strong, pleasant,	- - - -	Good, but mild.
28	30° / 20°	9 h. / 15 h.	11	Unaltered, slight gas,	Acid,	Pungent, sour,	Slight, pleasant,	Musty, but pleasant.
29	23°	48 h.	5	Slightly changed,	Alkaline,	Pleasant,	Slight,	Good, mild.
30	25°	48 h.	2	Slightly changed,	Alkaline,	Sweet, strong,	Excellent,	Prominent flavor, excellent.
31	25°	48 h.	1	Slightly changed,	Alkaline,	Sweet,	Good,	Rather mild.
				Organism No. 27.				
32	25°	1 d.	6	Slightly thickened,	Alkaline,	Musty, sour,	Unpleasant,	Bitter and bad.
33	25°	1 d.	3	Slightly thickened,	Alkaline,	Disagreeable,	Bitter,	Bitter and bad.
34	28°	1 d.	7	Slightly thickened,	Alkaline,	Bad,	Bitter,	Strong and unpleasant.
35	28°	1 d.	4	Slightly thickened,	Alkaline,	Disagreeable,	Bitter,	Bitter and bad.
36	25°	1 d.	—	Slightly thickened,	Neutral,	Sweet,	Slight, unpleasant,	Slightly bitter.
37	28°	1 d.	7	Slightly thickened,	Alkaline,	Unpleasant,	Bitter,	Bitter and bad.
38	20°	2 d.	21	Slightly thickened,	Alkaline,	Unpleasant,	Bitter,	Bitter and bad.
39	20°	2 d.	7	Slightly thickened,	Alkaline,	Unpleasant,	Bitter,	Bitter and bad, burning taste on tongue.
40	20°	2 d.	4	Slightly thickened,	Alkaline,	Unpleasant,	Bitter,	Bitter and bad.
41	35°	2 d.	14	Over-ripened, worthless, not churned.	- - -	- - - -	- - - -	—
42	25°	2 d.	21	Thickened,	Alkaline,	Vile,	Bitter,	Bitter, burning, worthless.
43	20°	2 d.	5	Thickened,	Alkaline,	Vile,	Bitter,	Bitter, burning, worthless.
44	20°	2 d.	—	So badly ripened that it was not churned.	—	—	—	—
45	25°	2 d.	10	Slightly thickened,	Alkaline,	Vile, unpleasant,	Bitter, strong,	Bitter, burning, worthless.
46	20°	2 d.	1	Slightly thickened,	Alkaline,	Vile, unpleasant,	Bitter, strong,	Bitter, burning, worthless.

TABLE 12.—*(Continued.)*

Exp't No.	Temperature and Time of Ripening.	Age of Culture.	Appearance of Ripened Cream.	Reaction of Ripened Cream.	Odor of Ripened Cream.	Taste of Ripened Cream.	Butter.
			Organism No. 5.				
47	24° 1 d.	—	Slightly thickened,	Acid,	-	-	Rather gummy, not specially good.
48	27° 1 d.	—	Rather thick, foamy,	Acid,	Slight,	Soured,	Strong, rather disagreeable flavor, slightly burning sensation.
49	20° 1 d.	—	Somewhat foamy,	-	Peculiar,	Unpleasant,	Good flavor.
50	20° 21 h.; 37° 3 h.	—	Not thickened,	-	Slight,	-	Very slight taste.
			Organism No. 16.				
52	27° 1 d.	Ag'r	Cream, very thick, frothy,	Acid,	Unpleasant,	-	Churns with difficulty, mild, unpleasant flavor, not good.
53	37° 7 h.; 33° 17 h.	3	Thin,	Acid,	Unpleasant,	Sour, not bitter,	Strong, over-ripened.
54	20° 2 d.	4	Frothy, with gas bubbles,	Acid,	Sour, prominent,	Slightly sour,	Good, not very much taste.
55	20° 2 d.	Ag'r	Not thick,	Acid,	Pleasantly sour,	Sour,	Too strong, seemingly over-ripened.
56	20° 22 h.; 37° 3 h.	18	Slightly thick,	Acid,	Sour, unpleasant,	Sour, pleasant,	Slight taste, not very good.
57	23° 1 d.	4	Slightly thickened,	Acid,	-	Slightly sour,	Good, slightly sour taste.
			Organism No. 16i.				
58	37° 7 h.; 33° 17 h.	2	Thin, unaltered,	Acid,	Unpleasant,	Bitter, strong,	Intensely bitter.
59	20° 1 d.	2	Unaltered,	Acid,	Neutral,	Bitter, sour,	Sour, bitter and burning.

60	20°	2 d.	Ag'r	Unaltered, - - -	Acid, -	Peculiar, - -	Sour, bitter, - -	Strong and bitter with burning taste.
61	28°	1 d.	3	Moderately thick, - -	Very acid,	Like ripened cream,	Sharp, sour, - -	Quite good, slight burning taste.
62	20°	1 d.	1	Thickened, - - -	Acid, -	Fresh, creamy smell,	Good, - - -	Good taste, but too strong.
63	37°	1 d.	1	Thin, thick layer on top,	Very acid,	Strong, sickish, -	Disagreeable, sharp,	Strong, bitter, burning, very bad.
64	28°	1 d.	2	Unaltered, - - -	Acid, -	Disagreeable, sour, -	Sour, - - -	Strong and disagreeable.
65	28°	1 d.	4	Unaltered, - - -	Acid, -	Strong, sour, - -	Very sour, - -	Bitter and burning.
66	23°	2 d.	1	Unaltered, - - -	Acid, -	Strong, sour, - -	Very sour, - -	Bitter and burning.
				Organism No. 18.				
67	28°	1 d.	13	- - - - -	Acid, -	Sour, penetrating, -	Slightly bitter, -	White, fair, but peculiar taste.
68	37°	1 d.	12	Thick, full of gas, - -	Strong, acid,	Oily, musty, - -	Clear, sour, - -	Strong, oily, cheesey, worthless.
69	37°	1 d.	—	Thick, - - -	Acid, -	Sour, disagreeable, -	Sour, sickish, - -	Strong, rank, bad taste.
70	20° 22 h. / 37° 3 h.		6	- - - - -	Neutral, -	Slight, unpleasant, -	Unpleasant, - -	Moderately good, slightly burning.
71	20° 22 h. / 37° 3 h.		2	- - - - -	Acid, -	Bitter, - - -	Bitter, - - -	Slightly strong, rank taste.
72	25°	1 d.	2	Not thickened, - -	Acid, -	Sickish, strong, -	Sour, - - -	Strong, rank taste, over-ripened.
73	28°	1 d.	—	Not thickened, - -	Acid, -	Sickish, strong, -	Sour, - - -	Slightly strong, rank taste.
				Organism No. 19.				
74	20°	1 d.	—	No change, - - -	Neutral, -	Scalded taste, - -	- - - -	Tastes of scalded milk.
75	37°	1 d.	—	Thickened, oily, full of gas bubbles, strong,	Acid, -	Musty, - - -	Sour, - - -	Peculiar, cheesey, bad.
76	20°	1 d.	10	Unchanged, - -	Alkaline, -	Unpleasant, cheesey,	- - - -	Tasteless.
77	20°	2 d.	4	Unchanged, - -	Alkaline, -	Slight, - - -	Smarty, sweet, -	Moderately good, but rather strong.

TABLE 12.—*(Continued.)*

Exp't No.	Temperature and Time of Ripening.	Age of Culture.	Appearance of Ripened Cream.	Reaction of Ripened Cream.	Odor of Ripened Cream.	Taste of Ripened Cream.	Butter.
			Organism No. 20.				
78	23° 1 d.	3	Slightly thick, - -	Acid, -	- - - - -	- - - - -	Good flavor, texture sharp, slightly pungent.
79	20° 22 h. / 37° 2 h.	—	Unchanged, - -	Neutral, -	- - - - -	Sweet cream, - -	Good, but not enough taste.
80	28° 1 d.	—	Not thickened, gas, -	Acid, -	Sour, slightly musty,	Slightly sour, - -	Rather strong and unpleasant taste, not good.
81	28° 1 d.	7	Not thickened, - -	Acid, -	Musty, - - -	Musty, sour, - -	Slight musty taste, unpl's'nt.
82	20° 2 d.	21	Gas accumulates, thin, -	Acid, -	Pleasant, like ripened cream,	Slightly sour, - -	Quite good.
			Organism No. 21.				
83	20° 2 d.	9	Quite thick, no gas, -	Acid, -	Peculiar, - -	Slightly sour, - -	Good, rather too strong.
			Organism No. 26.				
84	27° 1 d.	—	Thin, - - - -	Alkaline, -	Fresh, rich, - -	Good, - - -	Excellent, rather mild.
85	20° 2 d.	7	Unaltered, - - -	Alkaline, -	Sweet, pleasant, -	Sweet, pleasant, -	Very mild.
86	20° 2 d.	7	Moderately thick, - -	Neutral, -	Slight, - - -	Pleasant, creamy, -	Good, mild.
87	23° 1 d.	15	Unchanged, - -	Alkaline, -	Slight, - - -	Sweet, - - -	Good.
88	23°? 1 d.	5	Unchanged, - -	Alkaline, -	Pleasant, slight, -	- - - -	Good, mild.
89	23°? 1 d.	—	Unchanged, - -	Neutral, -	Pleasant, slight, -	- - - -	Good, mild.
			Organism No. 31.				
90	23° 1 d.	—	Thickened, - - -	Neutral, -	Decaying, - -	Bad, - - -	Fluffy, with bad taste and worthless.
91	23° 1 d.	3	Not thick, - - -	Alkaline, -	Peculiar, - -	Slight, - - -	Very mild, somewhat smarting.
92	28° 1 d.	—	Thickened, - - -	Alkaline, -	Bad, - - -	Bad, - - -	Sickish and worthless.

SUMMARY OF THE RESULTS SHOWN BY THE TABLE.

From the experiments thus tabulated (see table 12 before) can be drawn certain general results as to the effect of the different species. These conclusions, with some further details, may be summarized as follows:

Species No. 2.

From the table it will be seen that No. 2 makes good butter though of a rather mild flavor, and that it makes little difference whether the ripening be carried on two days at 20° or one day at a higher temperature, but the best results were obtained after forty-eight hours ripening at 20°. Except with a very high temperature No. 2 will always produce good butter. The flavor, while excellent, is not quite like that of first class creamery butter. We see further that it makes little difference in the results whether the culture of inoculation be a fresh culture (one or two days) or an older one. Practically it was found more convenient to use fresh cultures. Everyone to whom the butter was submitted regarded it as excellent but mild, and it was frequently preferred to creamery butter with which it was compared. Slight differences in the results of these tables are probably due to errors introduced by other species accidentally present in the milk. It was noticed in most experiments that the ripening, if prolonged, injured the texture of the fat so that the grain of the butter was not good.

Species No. 22.

It will be seen from the table that No. 22 makes good butter but also rather mild. When compared with No. 2 in parallel experiments, preference was usually given to No. 2, although there was little difference between the two. It will be seen also that No. 22 ripens cream slowly, and forty-eight hours at 20° was never too long to produce the best results. It would stand twenty-four hours at 28° without difficulty, but 35° rapidly destroyed the cream and ruined the butter. In experiment No. 22 the milk and cream were slimy, a fact which explains the bad butter. Nos. 2 and 22 produced better butter than any other species of bacteria experimented with. Frequently the butter was pronounced decidedly superior to creamery butter with which it was compared.

Species No. 27.

No. 27 uniformly ruins the butter whenever it has an opportunity to grow in the cream. It grows readily at all temperatures and always produces bad smelling cream and bitter butter. The effect was the same whether allowed to act one or two days, although more noticeable, of course, in the longer periods. By reference to the tables it is seen that Nos. 2 and 22 produce an excellent, mild-flavored butter under identically the same conditions as those under which No. 27 produces a very bad butter. Experiments No. 33 and one of the same date, not in the tables, were especially instructive. The two lots of cream for the day were both inoculated with No. 27 and then pasteurized at 70°. One was then inoculated with No. 27 and the other with No. 2. Both were then ripened twenty-four hours. One gave the bitter butter of No. 27, the other the good butter of No. 2; showing that pasteurizing would destroy the organism No. 27, should it chance to be in the cream.

Species Nos. 2, 22 and 27.

These three organisms were those upon which the largest number of experiments was performed, inasmuch as they proved to be the most promising for the purpose for which the experiments were originally designed. The other organisms were not used so many times for the purpose in our experiments, and the results are therefore not quite so definite. These three were finally chosen for the exhibit at Chicago. Nos. 2 and 22 to show species producing good butter, and No. 27 a species producing bad butter. Later No. 16*i* was added to the list.

Species No. 5.

Experiments 47–50 were among the earlier experiments and the cream was inoculated directly from an agar culture. In experiment 49 the cream, in order to compare with experiment 50, was not pasteurized. Plate cultures were made from the ripened cream of both, and while No. 49 showed a variety of species, ripened cream of No. 50 was nearly a pure culture. These experiments were insufficient to determine satisfactorily the effect of No. 5 on butter.

Species Nos. 16 and 16i.

From experiments 52–65 it will be seen that Nos. 16 and 16*i* differ plainly in their effect on butter. No. 16*i* always produces

bitter, sour butter, while No. 16 made very good butter in all cases. So marked was the bitter taste of 16*i* that it was used in many experiments at the Columbian Fair to show the injurious effect of certain species of bacteria on the butter aroma. The difference between these two organisms is very remarkable considering that their specific characters are almost identical. After having worked out the characters as shown on page 51, I concluded that the species were identical, but repeated experiments in ripening cream showed an absolutely uniform difference in the resulting butter, and the conclusion was inevitable that at least there was a physiological difference between them. This result, while surprising, is not unique, for other species or varieties have been found to be separated by equally slight differences. Nencke (*Cent'b't. f. Bact. u., Par.* IX, p. 304) has found a bacillus differing from *B. coli commune* only in producing a different chemical form of lactic acid. Other instances might be cited.

Species No. 18.

From experiments 68–73 it will be seen that No. 18 produces very poor butter. It is not so bad as that of Nos. 27 or 16*i* but is of a decidedly poor quality.

Species No. 19.

In experiment No. 74 the cream was heated to 100° instead of 70° which explains the scalded milk taste. No. 19 will not grow at 35° (see page 52). The ripening of the cream in experiment 75 was not, therefore, due to No. 19 but to the organisms which resisted 70° used in pasteurization and were forced into rapid growth by the high temperature of ripening. From experiments 74–77 it will be seen that No. 19 is not favorable to butter ripening, butter acquiring a rather strong taste under its influence. The butter was not very bad, however, and would readily pass in market as a second quality butter.

Species No. 20.

The butter in experiments Nos. 78–82 differed somewhat in quality, sometimes being quite good and at others not so good. The differences were very slight, however, and would lead to the conclusion that No. 20 produced very slight effect on butter flavor. So slight was it that the organism was soon abandoned as unpromising.

Species No. 26.

In experiment 89 the cream was inoculated with the buttermilk from experiment No. 87. This species produces excellent butter.

Species No. 31.

No. 31 was obtained from water of a brook. Its effect on butter was universally bad.

In addition to the organisms above referred to in tables, cream has been ripened with quite a number of other species not described. A few well known species of bacteria were also used as follows:

A culture of *Bacillus acidi-lactici* received from Germany was found to make unpleasant-tasting butter, as has been previously shown by Storch.

The species *Micrococcus freudenreichei*, received through the kindness of M. Freudenreich, was used according to the method above described, and was found to produce a good-tasting though very mild butter, which was, however, rather soft and fluffy in consistency.

Bacillus katz produced butter with a tolerably good taste, and would be regarded as moderately good butter.

Bacillus schafferi was found in several experiments to produce butter with an unpleasant taste, which was always regarded as a poor quality of butter.

Several points of general interest have been shown by the experiments above given, which may be summarized here. In the first, place, it has been proved in all cases that a temperature as high as 35° C., even for a few hours, is almost sure to over-ripen the cream and produce bad butter. Moreover, it was found that pasteurized cream, even though not subsequently inoculated, would become ripened in twenty-four hours at this temperature, indicating, of course, that the spores left in the cream developed rapidly enough at that temperature to produce marked results. Evidently a temperature of 35° cannot be used for ripening in such experiments. Temperatures of 28° and 23°, however, could be used for twenty-four hours without difficulty, the uniformity of the experiments at this temperature showing that the cream was ripened chiefly by the artificial culture inoculated. At the temperature of 20° the ripening could be continued for two days without trouble, and in no case was an over ripening produced in this time with any of the pure cultures used.

The experiments, as stated in the introduction, have always been performed in pairs, and the separate consideration of the results of some of these pairs will be instructive as indicating the success of the experiments, and the striking results of different species under similar conditions. A few such pairs only will be selected for description.

On February 4th two lots of cream were pasteurized as usual, one inoculated with No. 2, the second with No. 27. Both of them were allowed to stand at 23° for two days. At the end of that time, No. 2 cream had a slight musty smell, with a neutral reaction, and produced a very good butter, which was quite mild. No. 27 at the same time produced a vile-smelling alkaline cream, which resulted in a bitter, vile-tasting butter which was very poor.

On January 26th two lots of cream were pasteurized, one inoculated with No. 22, the other with No. 2. They were ripened one day at a temperature of 23°. Each of them produced a sweet-smelling, sweet-tasting, alkaline cream. Each produced an excellent grade of butter, and it was difficult to choose between them.

On January 21st the two lots of cream were heated as usual, one inoculated with No. 26, the second with No. 27. Both were left at a temperature of 20° for two days. Both became alkaline with a pleasant, mild odor. No. 26 had a pleasant, sweet taste, and gave butter with scarcely any aroma. No. 27 gave a sour-tasting cream, resulting in a bitter butter with a smarting taste.

January 23d both lots of cream were sterilized as usual, one inoculated with No. 16*i*, the second with No. 2. Both were placed at 27° for one day. No. 16*i* gave an acid, disagreeable-tasting and smelling cream, and a strong, disagreeable aroma to the butter. No. 2 produced a slightly acid cream with a pleasant odor and taste, and an excellent quality of butter.

On January 20th two lots of cream were heated as usual, one inoculated with No. 18, the second with No. 2. Both were left at 28° for one day. No. 18 produced a sickish-smelling cream, slightly sour and bitter, with a strong, rank taste. No. 2 produced slightly alkaline, sweet-tasting cream, with a pleasant, mild-tasting butter.

January 16th two lots of cream were heated as usual, one inoculated with No. 23, the second with No. 18. Both were left at 20° for twenty-two hours. The cream of both became slightly acid. Both were then placed at 37° for three hours. No. 23

became slightly more acid but produced very good butter. No. 18 became decidedly acid and bitter and produced strong, rank butter.

The consideration of the pairs of experiments as shown above, plainly shows the difference in the butter of different species of bacteria when used in ripening the cream, and, in addition, indicates that the method of experiment was rigid enough to obtain at least approximate results in all cases.

Another point brought out clearly in these experiments was the effect of the washing of butter. Nearly all of the flavor produced by the ripening of the cream was in the buttermilk, and the taste of the butter was very much more prominent without thorough washing than it was after such washing. If the butter was washed long enough, all of the aroma would be washed out, while without any washing at all, the taste was most prominent. The butter aroma is then not due to changes in the fat, but to some other constituents of the cream. For this reason it was our custom to taste the butter before any washing had occurred, as well as after the working, and in this way a stronger effect was noted and the differences between the organisms made out with more ease. This fact, that the aroma is due to the buttermilk, is not a new one, but it was plainly brought out by the experiments.

It should be stated that in all of these experiments the differences in flavor of the resulting butter were less than had been anticipated before the experiments began. The effect upon the taste and flavor of the ripened cream of the different species of bacteria was very marked indeed, and the effect upon the taste of the butter before washing was equally striking. After the washing and the working, which removed a considerable portion of the buttermilk, the differences in flavor were very much less noticeable, so much so that in some of the experiments it required the utmost attention to make out the appropriate differences between different specimens of butter. It is true that the differences above noted in the experiments were always seen in the specimens of butter tested, but it is equally true that those differences were not in many cases very striking ones. Many of the forms of butter which have been described as poor or moderate would probably pass muster as tolerably good butter. At the same time, in the case of a few of the organisms, especially No. 27 and No. 16*i*, the effect upon the butter was in itself very

striking, and no one failed to perceive the marked disagreeable flavor. The total result of these experiments, however, has been to indicate that the effect upon the flavor of butter, while noticeable, is not so striking as was at the outset expected. At the same time the effect was sufficient to make the differences between the fine, delicately flavored butter and the unpleasant, strong-tasting butter which results from an improper ripening; in other words, the differences between the very highest quality of butter and that of an inferior grade.

Another point of much significance was noted. Of the large variety of species of bacteria found in ripening cream the number which produce poor butter is very small. Among the 20 species already experimented with, only three produced strikingly bad effects, while all the rest gave good butter or had no marked influence. This is a matter of considerable importance as bearing upon dairy interests. It indicates that no particular species of bacteria is needed to produce a good aroma, but that nearly all of the species liable to get into the cream under normal conditions, will give moderately good results. Some, indeed, are better than others for the purpose, and some really produce injurious effects, but the majority of species are either directly advantageous or neutral in their action. It must be remembered, however, that the source of these organisms was cream from first-class creameries, where the beneficial species must be supposed to outnumber the injurious ones. What result would have been obtained if a lot of cream from an inferior dairy had been used as a starting point, cannot be stated, but the result remains that good conditions may be depended upon to produce favorable varieties of bacteria in abundance.

Somewhat akin to the above is the general observation that no single species produced a typical ripening of cream, or the usually expected flavor in the butter. Although many of them produced excellent butter, yet in every case the verdict would be given that the flavor was not exactly that of normally ripened butter. This is not to be wondered at, for it is hardly to be expected that any one species would produce the same result as that produced by many species growing together. Experiments with combinations of species have therefore been undertaken, but the results are not yet complete.

It will be noticed that most of the species experimented with, produced an alkaline reaction, the reason being that a large part

of the species isolated from ripening cream, showed this peculiarity. The few acid-producing species isolated did not produce so good effects on the butter as the alkaline producing species. Further experiments with acid-producing species are needed, however.

SUMMARY.

The most important points taught by these experiments may be summarized as follows:

1. Different species of bacteria grown in the cream while ripening have different effects upon the butter flavor. The differences in the resulting butter aroma are not very prominent in most cases, but are decided enough to make the difference between a first-class grade of butter and a second class.

2. Pasteurizing cream at 70° C. will so largely destroy the bacteria in it, that a pure culture of bacteria subsequently inoculated will produce its proper effects, not materially affected by the few organisms left in the cream after pasteurization.

3. Most species of bacteria found in cream of a good creamery produce good butter. The number which injure the flavor of the butter is small.

4. No one species of those experimented with, when used alone for ripening cream, produces a typically flavored butter, though many of them produce butter which is excellent in flavor and which was preferred to that of the normal ripening.

A STUDY OF RATIONS FED TO MILCH COWS ON SIXTEEN DAIRY FARMS IN CONNECTICUT.

BY CHAS. D. WOODS AND C. S. PHELPS.

In the Report of this Station for 1890 (pages 180 and 181), in an article by Professor Atwater on the fuel value of feeding stuffs, reference was made to six rations fed by leading New York dairymen and compiled by the New York State Station.* These were cited as illustrations of the wide range in the quantities of protein and of total estimated energy (fuel value) in the rations on different farms, and the importance of a more thorough study of actual feeding practice of dairymen. The hope was then expressed that "circumstances may be such as to permit an inquiry regarding kinds and amounts of feeding stuffs used by Connecticut dairymen."

During the winter of 1892–3, it was found practicable to begin such an investigation. For this purpose, Mr. Harry G. Manchester, a graduate of the Storrs School of the class of 1891, was employed as a special representative of the Station, to visit different dairy farms in the State, and make systematic observations of the cows, their feeding, care, milk-production and kindred subjects.

Each herd was selected by one of us (C. S. P.), after a personal inspection or after sufficient correspondence to satisfy ourselves of its fitness for the proposed test, and was frequently visited while the test was being made.

Mr. Manchester usually went to a farm on a Monday morning, arriving in time to begin the test at noon of that day, and remaining until the following Saturday. The interval between Saturday noon and the following Monday was long enough to go to another place with the needed apparatus and make preparations for a test to begin at noon on Monday. This made a period of five days at each place, and with two exceptions this was the

* New York State Station Bulletin No. 17, (new series).

length of time given to the study of each of the sixteen herds visited. In this first winter's work, which was regarded as preliminary to an investigation that might extend over a series of years, it was thought better to examine a relatively large number of herds, each during a short period, than to make the periods longer and the number of herds less.

The chief points upon which information was obtained were:—

Number of animals in the herd.—In considering the number of animals, only those which came into the test were included. Usually these were all of the cows on the farm which were in milk at the time of the test.

Breed, age and approximate weight of each cow.—The breed and age were obtained as accurately as possible from the owner. Since it was not practicable to take to the farm scales large enough on which to weigh the cows, the weights were estimated. This estimation was made in each case by the Station representative, and it is hoped that the errors of judgment may run more or less equally through all the herds examined.

Number of months since last calf.—In most cases the time at which the cow dropped her last calf was known.

Number of months till due to calve.—There was, of course, more or less uncertainty in this regard.

Weights of milk-flow for the five days.—The milk of each cow at each milking was weighed as soon as milked, to the nearest tenth of a pound, by the Station representative.

Percentages and amounts of butter-fat in the milk.—A sample of the milk of each cow, at each milking, was taken for the determination of the quantity of butter-fat. The Babcock method of fat determination was employed. From the percentages of butter-fat in the milk, and the total weights of the milk, the daily yields of butter-fat were obtained.

Kinds and weights of foods used.—The feeder was requested to use the same kinds and amounts of feeding stuffs during the test period as he had previously used. The quantity for each animal was weighed by the Station representative just before feeding. Any portions of the food left uneaten by the cows were carefully weighed, and due allowance was made for these uneaten residues in estimating the amounts daily eaten. During the test, usually on the third day, samples of each food used were carefully taken and at once sent to the laboratory for analysis. From the results

of the analyses and the weights fed, the total nutrients (protein, fats, nitrogen-free extract and fiber) fed each day were calculated. By the use of digestion coefficients, more or less accurate estimates were made of the weights of digestible nutrients in each day's ration.

The names and post-office addresses of the owners of the herds studied by the Station are given in the following list, together with the dates at which the Station representative was at the farm. At the left, in the first column of figures, there is given a reference number for each herd. In the remaining tables and in the discussion, the herds and the rations fed are referred to by these reference numbers.

Names and Post-office Addresses of Owners of Herds Studied, Dates at which they were visited and Reference Numbers of Herds.

No. of Herd.	Name and P. O. Address of Owner.	Date of Test.
		1892.
1, - -	W. S. Crane, Willimantic.	Nov. 30–Dec. 2.
2, - -	N. D. Potter, South Coventry.	Dec. 5–9.
3, - -	Samuel Stockwell, West Simsbury.	Dec. 12–17.
4, - -	C. P. Case, Simsbury.	Dec. 19–24.
5, - -	Edward Manchester, West Winsted.	Dec. 26–31.
		1893.
6, - -	Isaac Barnes, Collinsville.	Jan. 2–7.
7, - -	Elbert Manchester, Bristol.	Jan. 9–14.
8, - -	Edward Norton, Farmington.	Jan. 16–21.
9, - -	H. W. Sadd, Wapping.	Jan. 23–28.
10, - -	John Thompson, Broad Brook.	Jan. 30–Feb. 4.
11, - -	E. F. Thompson, Warehouse Point.	Feb. 6–11.
12, - -	R. E. Holmes, West Winsted.	Feb. 13–18.
13, - -	James B. Blivin, Baltic.	Feb. 27–Mch. 4.
14, - -	George W. Woodbridge, Manchester Green.	Mch. 6–11.
15, - -	Harvey S. Ellis, Vernon Centre.	Mch. 13–18.
16, - -	Chas. P. Grosvenor, Abington.	Mch. 20–25.

Table 13, which follows, gives a summary of the statistics of the herds visited. In this table and in the others which follow, the following abbreviations are used:

ABBREVIATIONS USED IN REPORT OF COW DIETARIES.

Ay. = Ayrshire.	Gy. = Guernsey.	P. = Pure Breed.
Dev. = Devon.	Hol. = Holstein.	R. = Registered.
Dur. = Durham.	Jy. = Jersey.	Sw. = Swiss.
G. = Grade.	Nat. = Native.	

TABLE 13.

Condensed Statistics of Sixteen Dairy Herds Studied by the Station.

Number of Herd.	Length of Test.	Number of Animals in Test.																Average Weight.	Average Age.	Mos. Since last Calf.
		Ayrshire.		Devon.		Durham.		Guernsey.		Holstein.		Jersey.		Swiss.		Native.	Total.			
		R.	G.	R.	G.	R.	G.	R.	G.	R.	G.	R.	G.	R.	G.					
1,	3	1	–	1	–	–	–	8	1	–	–	–	3	–	–	–	14	900	5	10
2,	4	–	–	–	–	–	–	–	–	–	–	–	17	–	–	1	18	900	7	5
3,	5	–	–	–	–	–	–	1	–	–	–	3	8	–	–	1	13	800	5	6
4,	4	–	–	–	–	–	–	–	–	–	–	1	18	–	–	–	19	800	5	4
5,	5	–	1	–	–	–	–	–	1	–	2	–	5	–	–	6	15	800	6	4
6,	5	–	–	–	–	–	–	–	1	–	–	1	3	3	2	–	10	900	6	7
7,	5	–	2	–	–	–	1	–	–	–	5	–	6	–	–	3	17	825	6	6
8,	5	–	–	–	–	–	–	5	6	–	–	–	–	–	–	1	12	750	5	3
9,	5	–	–	–	–	–	–	5	6	–	–	–	–	–	–	1	12	900	7	5
10,	5	–	–	–	–	1	–	–	–	–	–	4	13	–	–	–	18	850	5	3
11,	5	–	–	–	–	–	–	–	–	–	–	–	18	–	–	–	18	825	5	5
12,	5	–	–	–	–	–	–	–	–	3	–	1	9	–	–	7	20	875	6	7
13,	5	–	1	–	1	–	2	–	1	–	1	6	6	–	–	1	19	800	5	10
14,	5	–	–	–	–	–	–	–	–	–	–	–	10	–	–	–	10	875	7	4
15,	5	–	1	–	–	–	–	–	–	–	–	–	18	–	–	–	19	850	6	5
16,	5	–	–	–	7	–	–	–	3	–	1	–	4	–	–	5	20	900	6	7
		1	5	1	8	1	3	19	19	3	9	16	138	3	2	26	254	850		

As shown in table 13, the sixteen herds examined contained 254 milk-giving cows, or an average of about sixteen per herd. The smallest herd contained ten cows; the largest twenty. Seven breeds and grades were represented besides some animals of unknown pedigree. Forty-four cows, or 17 per cent. of the whole were of pure breed; 184, or 73 per cent. of the whole, were grades, and 26, or 10 per cent. of the whole, were "natives," that is, animals without any special breeding so far as known. One hundred and fifty-four, or 60 per cent. of the whole, were either pure or grade Jerseys, and 38, or 15 per cent. of the whole, were pure or grade Guernseys. While no effort was made to select herds of any particular breeding, it happened that three-fourths of all the animals of these herds were, to a greater or less extent, from stock originally from the Channel Islands.

The average ages of the animals of each of the sixteen different herds ranged from five to seven years, six being about the average age of the animals of all the herds taken together. The youngest animal was two years old (in third year) and the oldest was 17 years. Fifty-eight of the cows were under four years, 193

were between four and twelve, and three were over twelve years old. One hundred and sixty of the 196 animals which were four years old or older, were in the period of lactation (from flush to eight months past calving) during which the largest yields of milk and butter-fat are expected.

Tables 14 to 29 inclusive contain the results, in considerable detail, of the studies of the sixteen different herds. They are all alike in arrangement, and a description of one will serve for all. Each table contains the condensed results for a herd. Table 14, for instance, gives statistics for herd No. 1.

The first (upper) part of the table gives a reference number of each animal, its breed, age, weight and number of months since last calf. The smallest daily milk flow, the greatest daily milk flow and the total yield of milk for the five days are given in the next three columns. In the three following columns are given the lowest, highest and average percentages of fat found in the daily milk of each cow for the period of five days. The figures were obtained by adding together the five daily determinations and taking the average, hence this actual average is not always half way between the highest and lowest. The yield of fat is given in the last three columns of the first or upper part of the table. The minimum and maximum yields of fats were obtained by multiplying each day's milk by its percentage of fat; the lowest number thus obtained gives the minimum daily yield of fat, and the largest the maximum yield of fat. It is to be noted that these numbers are not the same as would have been obtained by multiplying the minimum and maximum daily milk flow by the minimum and maximum percentages of fat. The total yield of fat for the five days was found by taking the sum of the daily yields of butter-fat.

The second, or lower part of each table, gives the kinds and amounts of the different food materials eaten *per day per 1,000 pounds live weight*, and the weights of the total and digestible nutrients (protein, fats and carbohydrates) which they furnished. As stated previously, all of the different feeding stuffs used in these rations were analyzed, and from the results of these analyses the weights of the total nutrients furnished by the different coarse fodders and concentrated foods were obtained. The results of these analyses are given on pages 17–27 of this Report. The method employed in calculating the fuel value or potential

energy furnished by the different foods, is explained on page 17 of this Report.

The weights of digestible nutrients in the rations were obtained from the weights of total nutrients by the use of factors (coefficients of digestibility) obtained from the results of digestion experiments in this country and Germany. So far as possible, the factors obtained in American digestion experiments were employed. The following tabulation gives the digestion coefficients here employed.

Coefficients of Digestibility used in calculating the Digestible Nutrients in the Different Foods used in these Rations.

	Protein.	Fat.	Carbohydrates.	
			Nit.-free Ex.	Fiber.
	%	%	%	%
Wheat bran, - - - - - - -	78*	73*	66*	33†
Wheat middlings, - - - - - -	79*	85*	83*	33†
Linseed meal, - - - - - -	86†	90†	80†	50†
Cotton seed meal, - - - - - -	89*	100*	68*	33†
Pea meal, - - - - - - -	83*	54*	94*	26*
Corn meal, - - - - - - -	76†	92*	87*	58†
Corn and cob meal, - - - - -	76*	82*	84*	28*
Gluten meal, - - - - - - -	87*	88*	91*	33†
Malt sprouts, - - - - - - -	81†	68†	76†	64†
Good quality hay, - - - - - -	54*	54*	63*	55*
Poor quality hay, - - - - - -	45*	28*	60*	46*
Rowen hay, - - - - - - -	62†	46†	67†	64†
Corn stalks (stover), - - - - -	52*	52*	64*	66*
Corn silage, - - - - - - -	46*	80*	67*	67*
Potatoes, - - - - - - -	44*	13*	91*	—
Turnips, etc., - - - - - - -	84*	77*	95*	80*

* From results of American digestion experiments.
† From results of German digestion experiments.

In order to show the range of variation from day to day in the feeding of the same herd, the minimum and maximum daily rations per 1,000 pounds live weight are appended to these tables. The size of the rations is here measured by the total energy of the nutrients (protein, fats, etc.) A ration which is large in total energy may have a small amount of a given kind of food or a given kind of nutrients. Hence it sometimes happens that the minimum of one of the nutrients furnished by a certain kind of food in a given ration may be greater than the average of the nutrients in that ration. This is the case with the minimum of the coarse food in ration 1, table 13. The same may happen conversely, in the case of the maximum.

TABLE 14.

Dairy Herd No. 1.—Statistics of Herd, Nov. 30 to Dec. 2, 1892.

Reference No.	Breed.	Age.	Weight.	Months since Last Calf.	Milk Flow. Minimum per Day.	Milk Flow. Maximum per Day.	Milk Flow. Total in 5 Days.	Daily Percentage of Fat. Minimum.	Daily Percentage of Fat. Maximum.	Daily Percentage of Fat. Average.	Yield of Fat. Minimum per Day.	Yield of Fat. Maximum per Day.	Yield of Fat. Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Jy.	5	800	4	18.4	19.3	**94.6**	5.7	7.0	**6.2**	1.05	1.30	**5.95**
2	R. Gy.	2	865	8	8.2	8.9	**42.5**	5.5	6.5	**6.1**	.35	.53	**2.54**
3	G. Gy.	3	850	6	16.5	18.3	**87.0**	5.0	5.5	**5.3**	.87	.95	**4.54**
4	R. Gy.	3	825	18	10.7	11.4	**54.8**	5.9	6.8	**6.5**	.63	.75	**3.54**
5	R. Gy.	3	850	16	7.6	8.3	**40.2**	6.1	6.3	**6.2**	.45	.52	**2.47**
6	P. Dev.	7	825	6	26.4	29.5	**141.5**	4.2	4.7	**4.5**	1.13	1.41	**6.47**
13	R. Gy.	11	1100	21	11.1	13.2	**61.2**	4.8	5.6	**5.1**	.56	.69	**3.12**
14	P. Ay.	5	875	6	19.2	22.4	**105.0**	4.6	4.9	**4.8**	.89	1.10	**4.96**
15	R. Gy.	7	950	2	24.2	25.0	**122.9**	4.2	4.7	**4.5**	1.05	1.14	**5.52**
16	R. Gy.	3	950	2	19.6	20.1	**99.3**	4.3	5.0	**4.6**	.86	1.01	**4.60**
17	G. Jy.	3	850	3	21.4	23.7	**112.4**	4.0	5.8	**4.7**	.86	1.31	**5.29**
18	R. Gy.	7	1050	16	5.3	6.7	**30.5**	—	—	—	—	—	—
19	R. Gy.	3	875	18	10.8	12.6	**58.9**	4.6	5.9	**5.1**	.50	.71	**2.98**
20	G. Gy.	3	900	8	12.8	17.2	**72.8**	6.0	6.4	**6.1**	.77	1.05	**4.54**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Total. Fat.	Total. Nit.-free Ext.	Total. Fiber.	Total. Fuel Val. (En'gy.)	Digested Nutrients and Energy. Protein.	Digested. Fat.	Digested. Carbohydrates.	Digested. Nutritive Ratio.	Digested. Fuel Val. (En'gy.)
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Wheat bran,	2.8	.48	.13	1.53	.23	—	.37	.09	1.07	—	—
Middlings,	1.6	.29	.10	.80	.16	—	.23	.09	.71	—	—
Linseed meal,	1.8	.60	.16	.64	.15	—	.54	.15	.75	—	—
Gluten meal,	2.1	.50	.25	1.03	.11	—	.44	.22	.98	—	—
Total concentrated food,	8.3	1.87	.64	4.00	.65	14800	1.58	.55	3.51	—	11790
Hay,	11.0	.84	.34	4.70	3.18	—	.45	.19	4.71	—	—
Oat hay,	5.3	.44	.14	2.03	1.59	—	.24	.08	2.15	—	—
Ensilage,	27.3	.52	.22	2.88	1.40	—	.24	.17	2.87	—	—
Total coarse food,	43.6	1.80	.70	9.61	6.17	35700	.93	.44	9.73	—	21660
Total food,	**51.9**	**3.67**	**1.34**	**13.61**	**6.82**	**50500**	**2.51**	**.99**	**13.24**	**6.2**	**33450**
Minimum per day.											
Concentrated food	4.9	.76	.25	1.66	.26	6000	—	—	—	—	—
Coarse food,	42.7	2.06	.77	9.76	6.00	36400	—	—	—	—	—
Total,	47.6	2.82	1.02	11.42	6.26	42400	—	—	—	—	—
Maxim'm per day.											
Concentrated food	10.3	1.03	.57	3.41	.59	11800	—	—	—	—	—
Coarse food	44.4	3.15	.97	11.36	6.70	43500	—	—	—	—	—
Total,	54.7	4.18	1.54	14.77	7.29	55300	—	—	—	—	—

TABLE 15.

Dairy Herd No. 2.—Statistics of Herd from Dec. 5 to 9, 1892.

Ref. No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow. Min. per Day.	Milk Flow. Max. per Day.	Milk Flow. Total in 5 Days.	Daily Percentage of Fat. Min.	Daily Percentage of Fat. Max.	Daily Percentage of Fat. Average.	Yield of Fat. Min. per Day.	Yield of Fat. Max. per Day.	Yield of Fat. Total in 5 Days.*
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Jy.,	5	875	4	20.8	26.2	111.7	3.4	5.0	4.3	.73	1.31	4.88
2	G. Jy.,	7	850	4	20.7	21.8	106.7	4.6	5.2	4.9	.98	1.13	5.20
3	G. Jy.,	6	850	5	20.5	22.2	105.3	5.2	5.9	5.5	1.09	1.31	5.94
5	G. Jy.,	4	900	1	30.7	35.1	165.7	4.1	4.4	4.2	1.26	1.51	6.95
6	G. Jy.,	8	825	7	14.7	17.8	81.7	4.7	5.1	4.9	.74	.85	4.01
8	G. Jy.,	9	900	7	17.1	19.5	91.5	4.9	5.4	5.2	.92	1.05	4.78
9	G. Jy.,	7	900	7	16.9	19.1	92.4	4.4	5.0	4.7	.83	.96	4.43
10	G. Jy.,	4	900	2	24.6	26.5	129.1	4.6	5.7	5.0	1.13	1.51	6.50
11	G. Jy.,	4	850	8	5.1	7.0	30.7	5.1	6.0	5.8	.31	.38	1.78
12	G. Jy.,	4	875	8	11.8	12.6	61.0	6.4	7.0	6.4	.67	.88	3.93
13	G. Jy.,	4	850	4	24.0	26.3	124.1	5.1	5.5	5.4	1.32	1.34	6.64
14	G. Jy.,	6	850	4	15.8	17.7	84.4	5.5	5.8	5.6	.89	1.04	4.81
15	G. Jy.,	8	850	6	19.5	22.7	105.4	5.0	5.4	5.3	1.05	1.23	5.59
16	G. Jy.,	7	825	1	22.5	24.3	118.9	4.1	5.1	4.7	1.00	1.19	5.59
17	G. Jy.,	8	875	10	15.4	17.3	82.3	4.0	4.8	4.5	.62	.80	3.70
18	G. Jy.,	7	900	7	17.0	19.3	91.5	4.4	5.0	4.7	.83	.97	4.35
19	Native,	10	1000	9	21.0	24.1	110.5	3.5	3.9	3.7	.76	.88	4.03
20	G. Jy.,	10	975	2	22.6	25.9	124.6	4.3	4.8	4.6	.97	1.22	5.68

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Total Nutrients and Energy. Fat.	Total Nutrients and Energy. N.-free Ext.	Total Nutrients and Energy. Fiber.	Total Nutrients and Energy. F. Val. (En'gy)	Digested Nutrients and Energy. Protein.	Digested Nutrients and Energy. Fat.	Digested Nutrients and Energy. Carbo-hyd's.	Digested Nutrients and Energy. Nu. Ratio.	Digested Nutrients and Energy. F. Val. (En'gy)
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Middlings, -	4.7	.73	.25	2.51	.48	—	.58	.21	2.24	—	—
Gluten meal, -	3.7	1.44	.18	1.69	.06	—	1.25	.16	1.56	—	—
Provender,† -	3.0	.34	.13	2.02	.16	—	.22	.12	1.78	—	—
Total concentrated food, - -	11.4	2.51	.56	6.22	.70	19900	2.05	.49	5.58	—	16300
Good hay, - -	7.2	.56	.21	3.01	1.97	—	.30	.11	2.98	—	—
Poor hay, - -	2.2	.19	.06	.90	.62	—	.09	.01	.83	—	—
Ensilage, - -	55.3	.74	.30	5.26	3.41	—	.35	.24	5.80	—	—
Total coarse food,	64.7	1.49	.57	9.17	6.00	33400	.74	.36	9.61	—	20700
Total food, -	**76.1**	**4.00**	**1.13**	**15.39**	**6.70**	**53300**	**2.79**	**.85**	**15.19**	**6.1**	**37000**
Minimum per day.											
Concentrated food	10.6	2.19	.50	5.96	.64	18500	—	—	—	—	—
Coarse food, -	57.4	1.17	.44	7.39	4.84	26800	—	—	—	—	—
Total, - -	68.0	3.36	.94	13.35	5.48	45300	—	—	—	—	—
Maxim'm per day.											
Concentrated food	11.8	3.04	.60	5.90	.77	20600	—	—	—	—	—
Coarse food, -	66.2	1.80	.68	10.75	7.06	36500	—	—	—	—	—
Total, - -	78.0	4.84	1.28	16.65	7.83	57100	—	—	—	—	—

* Calculated from 4 days' test. † One part oats and two parts corn.

TABLE 16.

Dairy Herd No. 3.—Statistics of Herd from Dec. 12 to 17, 1892.

Reference No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow.			Daily Percentage of Fat.			Yield of Fat.		
					Min. per Day.	Max. per Day.	Total in 5 Days.	Min.	Max.	Average.	Min. per Day.	Max. per Day.	Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Gy.,	7	900	0	25.2	25.9	**128.3**	3.5	4.3	**3.8**	.91	1.11	**4.93**
2	G. Jy.,	7	900	12	14.0	16.1	**75.4**	5.6	6.3	**5.9**	.85	.94	**4.45**
3	R. Jy.,	6	850	13	21.8	25.3	**115.0**	4.1	5.9	**4.8**	.91	1.50	**5.58**
4	P. Jy.,	6	825	2	23.3	25.0	**121.2**	4.7	5.2	**4.9**	1.14	1.25	**5.99**
5	G. Jy.,	2	800	4	12.5	14.1	**65.9**	5.3	6.2	**5.6**	.68	.87	**3.72**
6	G. Jy.,	3	775	1	21.0	22.4	**107.7**	4.5	5.1	**4.7**	.97	1.08	**5.06**
7	G. Jy.,	4	775	17	5.4	9.6	**36.4**	5.8	7.4	**6.3**	.40	.58	**2.28**
8	R. Jy.,	3	800	13	11.5	12.7	**60.9**	5.8	6.4	**6.1**	.73	.78	**3.74**
9	G. Jy.,	5	825	2	25.2	27.1	**132.2**	4.7	5.1	**5.0**	1.22	1.37	**6.57**
10	G. Jy.,	4	750	4	15.7	18.2	**85.3**	4.6	5.9	**5.3**	.72	1.07	**4.52**
11	Native,	7	875	1	25.6	29.8	**140.2**	3.9	4.5	**4.1**	1.09	1.20	**5.75**
12	G. Jy.,	3	775	4	12.0	16.4	**69.9**	5.2	6.8	**5.9**	.68	1.03	**4.18**
13	G. Jy.,	2	650	5	9.5	10.7	**51.1**	4.0	6.5	**5.7**	.38	.66	**2.94**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy.					Digested Nutrients and Energy.				
		Protein.	Fat.	Nit.-free Ext.	Fiber.	Fuel Value (Energy).	Protein.	Fat.	Carbohydrates.	Nutritive Ratio.	Fuel Value (Energy).
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Cotton seed meal,	4.1	1.78	.38	1.15	.25	—	1.58	.38	.86	—	—
Gluten meal, -	3.1	.55	.30	1.73	.23	—	.48	.26	1.65	—	—
Hominy meal, -	3.5	.38	.28	2.23	.15	—	.33	.23	2.14	—	—
Total concentrated food, - -	10.7	2.71	.96	5.11	.63	19700	2.39	.87	4.65	—	16770
Hay, - - -	11.0	.61	.33	4.96	2.94	—	.33	.18	4.74	—	—
Stover, - -	9.3	.42	.20	3.86	2.66	—	.22	.10	4.23	—	—
Potatoes, - -	7.6	.17	.01	1.28	.04	—	.07	—	1.16	—	—
Total coarse food,	27.9	1.20	.54	10.10	5.64	33800	.62	.28	10.13	—	21180
Total food, -	**38.6**	**3.91**	**1.50**	**15.21**	**6.27**	**53500**	**3.01**	**1.15**	**14.78**	**5.7**	**37950**
Minimum per day.											
Concentrated food,	10.7	2.74	.96	5.12	.63	19800	—	—	—	—	—
Coarse food, -	25.8	1.11	.49	9.22	4.99	30600	—	—	—	—	—
Total, - -	36.5	3.85	1.45	14.34	5.62	50400	—	—	—	—	—
Maxim'm per day.											
Concentrated food,	10.7	2.68	.96	5.20	.62	19800	—	—	—	—	—
Coarse food, -	30.2	1.30	.58	11.06	6.37	37300	—	—	—	—	—
Total, - -	40.9	3.98	1.54	16.26	6.99	57100	—	—	—	—	—

TABLE 17.

Dairy Herd No. 4.—Statistics of Herd from Dec. 19 to 24, 1892.

Ref. No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow. Min. per Day.	Max. per Day.	Total in 5 Days.*	Daily Percentage of Fat. Min.	Max.	Average.	Yield of Fat. Min. per Day.	Max. per Day.	Total in 5 Days.*
		Yds.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Jy.,	5	790	3	11.1	13.1	**60.8**	5.1	5.4	**5.3**	.58	.69	**3.20**
2	G. Jy.,	7	900	2	19.0	22.2	**102.6**	4.8	5.5	**5.0**	.91	1.12	**5.16**
3	G. Jy.,	5	890	1	13.6	16.0	**73.5**	4.9	5.3	**5.1**	.68	.82	**3.76**
4	G. Jy.,	7	850	3	17.7	19.2	**91.4**	4.1	4.6	**4.3**	.72	.85	**3.90**
5	G. Jy.,	6	875	7	14.2	15.7	**75.6**	5.4	5.8	**5.6**	.82	.86	**4.21**
6	G. Jy.,	5	850	1	16.8	17.9	**87.8**	5.4	6.2	**5.7**	.94	1.11	**5.03**
7	G. Jy.,	5	825	4	15.6	19.0	**89.1**	5.7	6.7	**6.2**	1.05	1.14	**5.46**
8	G. Jy.,	2	775	8	10.4	11.1	**54.0**	5.6	5.8	**5.7**	.60	.63	**3.08**
9	G. Jy.,	2	775	7	11.7	15.0	**63.3**	5.2	5.6	**5.4**	.63	.78	**3.40**
10	G. Jy.,	4	875	1	11.2	11.4	**56.6**	5.7	6.1	**5.9**	.65	.70	**3.28**
11	G. Jy.,	8	900	10	9.8	12.5	**57.1**	6.7	7.1	**6.9**	.70	.84	**3.90**
12	G. Jy.,	2	810	7	10.0	13.5	**60.5**	4.8	5.3	**5.1**	.53	.66	**3.05**
13	G. Jy.,	2	600	0	13.2	14.4	**69.0**	3.6	4.3	**4.0**	.52	.58	**2.75**
14	G. Jy.,	2	600	1	12.5	13.5	**67.9**	4.7	5.4	**5.0**	.60	.73	**3.40**
15	G. Jy.,	8	900	2	21.9	24.1	**117.4**	4.1	4.4	**4.2**	.97	1.01	**4.93**
16	R. Jy.,	8	875	1	15.9	16.7	**81.6**	6.3	6.9	**6.6**	1.00	1.12	**5.35**
17	G. Jy.,	2	600	2	10.1	10.9	**55.1**	4.6	5.4	**5.0**	.49	.60	**2.75**
18	G. Jy.,	2	625	4	12.9	13.8	**67.4**	5.7	5.8	**5.8**	.74	.81	**3.93**
19	G. Jy.,	5	725	4	15.5	18.5	**85.1**	5.1	5.4	**5.3**	.80	1.00	**4.51**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Fat.	N.-free Ext.	Fiber.	F. Val. (En'gy)	Digested Nutrients and Energy. Protein.	Fat.	Carbo-hyd's.	Nu. Ratio.	F. Val. (En'gy)
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.
Wheat bran, -	3.7	.62	.18	2.03	.31	—	.48	.13	1.44	—	—
Cotton seed meal,	1.5	.71	.15	.42	.07	—	.63	.15	.31	—	—
Cob meal, - -	5.4	.48	.22	3.82	.16	—	.36	.18	3.24	—	—
Total concentrated food, - -	10.6	1.81	.55	6.27	.54	18300	1.47	.46	4.99	—	14000
Hay, - -	21.4	1.57	.71	8.90	5.00	—	.85	.39	8.36	—	—
Stover, - -	9.1	.57	.15	3.04	2.06	—	.30	.08	3.31	—	—
Total coarse food,	30.5	2.14	.86	11.94	7.06	43000	1.15	.47	11.67	—	25800
Total food, -	**41.1**	**3.95**	**1.41**	**18.21**	**7.60**	**61300**	**2.62**	**.93**	**16.66**	**7.0**	39800
Minimum per day.											
Concentrated food,	9.9	1.75	.51	5.74	.52	17050	—	—	—	—	—
Coarse food, -	29.3	2.05	.82	11.40	6.76	41050	—	—	—	—	—
Total, - -	39.2	3.80	1.33	17.14	7.28	58100	—	—	—	—	—
Maxim'm per day.											
Concentrated food,	11.2	1.79	.56	6.72	.54	19200	—	—	—	—	—
Coarse food, -	34.0	2.37	.92	13.17	7.85	47400	—	—	—	—	—
Total, - -	45.2	4.16	1.48	19.89	8.39	66600	—	—	—	—	—

* Calculated from four days' test.

TABLE 18.

Dairy Herd No. 5.—Statistics of Herd from Dec. 26 to 31, 1892.

Reference No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow.			Daily Percentage of Fat.			Yield of Fat.		
					Min. per Day.	Max. per Day.	Total in 5 Days.	Min.	Max.	Average.	Min. per Day.	Max. per Day.	Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Jy.,	3	700	3	13.6	14.9	**71.4**	4.2	5.2	**4.6**	.57	.75	**3.23**
2	G. Jy.,	3	725	1	24.1	24.8	**122.2**	3.6	4.3	**4.0**	.86	1.07	**4.83**
3	Jy.½Ay.	2	600	1	17.9	20.1	**97.4**	3.4	4.2	**3.7**	.64	.82	**3.58**
4	Native,	2	575	9	10.6	11.4	**54.0**	4.2	4.8	**4.6**	.46	.55	**2.52**
5	Native,	6	800	8	16.3	17.9	**84.1**	3.8	4.2	**4.1**	.64	.70	**3.44**
6	Native,	12	800	3	19.2	21.3	**100.0**	3.1	3.5	**3.3**	.61	.70	**3.33**
7	G. G.,	9	925	2	23.4	25.4	**122.6**	3.1	4.0	**3.7**	.78	.99	**4.58**
8	G. Jy.,	9	875	4	13.8	15.3	**70.3**	4.8	5.2	**4.9**	.68	.73	**3.47**
9	G. Hol.,	6	900	10	14.9	15.9	**76.6**	4.1	5.0	**4.5**	.62	.77	**3.44**
10	G. Hol.,	6	875	9	13.1	15.5	**71.9**	3.5	4.5	**3.9**	.52	.65	**2.82**
11	Native,	10	920	4	10.2	21.8	**92.3**	3.5	4.8	**3.8**	.39	.93	**3.51**
12	Native,	6	850	4	17.2	19.5	**90.5**	4.2	4.6	**4.4**	.76	.84	**3.95**
13	G. Jy.,	8	875	0	31.8	34.9	**166.3**	3.8	4.2	**4.0**	1.21	1.46	**6.59**
14	Native,	6	800	1	24.0	26.7	**128.1**	3.1	3.5	**3.3**	.79	.94	**4.18**
15	G. Ay.,	6	800	2	18.5	22.8	**104.7**	3.6	4.2	**3.9**	.72	.91	**4.08**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy.					Digested Nutrients and Energy.				
		Protein.	Fat.	Nit.-free Ext.	Fiber.	Fuel Val. (En'gy)	Protein.	Fat.	Carbohydrates.	Nutritive Ratio.	Fuel Val. (En'gy)
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.	—	Cal.
Grain,* - -	8.2	2.64	.88	3.39	.31	15500	2.20	.76	2.64	—	12200
Ensilage, - -	33.0	.77	.37	7.32	3.43	—	.35	.30	7.20	—	—
Hay, - - -	13.3	1.13	.36	5.11	3.88	—	.61	.19	5.35	—	—
Total coarse food,	46.3	.90	.73	12.43	7.31	43300	.96	.49	12.55	—	27200
Total food, -	**54.5**	**4.54**	**1.61**	**15.82**	**7.62**	**58800**	**3.16**	**1.25**	**15.19**	**5.7**	**39400**
Minimum per day.											
Concentrated food	8.0	2.65	.89	3.42	.31	15600	—	—	—	—	—
Coarse food, -	45.2	1.78	.67	11.39	6.77	39900	—	—	—	—	—
Total food, -	53.2	4.43	1.56	14.81	7.08	55500	—	—	—	—	—
Maxim'm per day.											
Concentrated food	8.1	2.63	.87	3.38	.31	15400	—	—	—	—	—
Coarse food, -	53.7	2.12	.82	14.16	8.20	49000	—	—	—	—	—
Total, - -	61.8	4.75	1.69	17.54	8.51	64400	—	—	—	—	—

* 100 lbs. wheat middlings, 125 lbs. gluten meal, 150 lbs. cotton seed meal.

TABLE 19.

Dairy Herd No. 6.—Statistics of Herd from Jan. 2 to 7, 1893.

Reference No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow. Min. per Day.	Milk Flow. Max. per Day.	Milk Flow. Total in 5 Days.	Daily Percentage of Fat. Min.	Daily Percentage of Fat. Max.	Daily Percentage of Fat. Average.	Yield of Fat. Min. per Day.	Yield of Fat. Max. per Day.	Yield of Fat. Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Jy.,	3	740	7	8.6	11.0	**51.2**	4.9	6.4	**5.3**	.52	.55	**2.71**
2	G. Jy.,	3	750	9	5.7	6.7	**31.5**	4.8	5.4	**5.0**	.30	.34	**1.61**
3	P. Jy.,	6	775	11	4.2	6.5	**28.2**	6.2	9.8	**7.2**	.34	.43	**1.98**
4	G. Jy.,	4	775	12	11.4	13.9	**62.2**	5.8	6.5	**6.1**	.67	.90	**3.79**
5	G. Jy.,	9	800	9	12.8	14.8	**68.5**	5.0	5.7	**5.3**	.66	.81	**3.57**
6	G. ½ Sw.	7	825	7	13.7	16.2	**73.3**	4.5	5.7	**5.0**	.63	.81	**3.65**
7	G. ¾ Sw.	5	900	2	22.7	26.1	**122.7**	2.5	4.1	**3.5**	.57	1.02	**4.28**
8	R. Sw.	5	1100	7	11.0	11.6	**56.3**	4.4	4.8	**4.7**	.48	.55	**2.62**
9	R. Sw.	9	1050	2	24.4	28.1	**133.6**	3.0	4.1	**3.5**	.81	1.14	**4.67**
10	R. Sw.	11	1100	5	20.2	22.6	**107.4**	3.7	4.0	**3.9**	.78	.90	**4.15**

Pounds of Food and Nutrients per day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Total. Fat.	Total. Nit.-free Ext.	Total. Fiber.	Total. Fuel Val. (En'gy)	Digested Nutrients and Energy. Protein.	Digested. Fat.	Digested. Carbohydrates.	Digested. Nutritive Ratio.	Digested. Fuel Val. (En'gy)
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Corn meal,	3.7	.37	.16	2.66	.04	—	.21	.15	2.33	—	—
Wheat middlings,	2.0	.38	.12	1.05	.13	—	.30	.10	.91	—	—
Cotton seed meal,	1.8	.81	.26	.48	.03	—	.72	.26	.34	—	—
Total concentrated food,	7.5	1.56	.54	4.19	.20	13400	1.23	.51	3.58	—	11100
Oat hay,	4.7	.26	.13	2.06	1.35	—	.14	.07	2.04	—	—
Hay,	14.4	.88	.41	6.43	3.83	—	.48	.23	6.16	—	—
Stover,	7.5	.35	.12	2.55	1.72	—	.18	.06	2.77	—	—
Total coarse food,	26.6	1.49	.67	11.04	6.90	38900	.80	.36	10.97	—	23400
Total food,	**34.1**	**3.05**	**1.21**	**15.23**	**7.10**	**52300**	**2.03**	**.87**	**14.55**	**8.1**	**34500**
Minimum per day.											
Concentrated food	7.4	1.56	.55	4.06	.22	13200	—	—	—	—	—
Coarse food,	25.6	1.44	.64	10.72	6.70	37800	—	—	—	—	—
Total,	33.0	3.00	1.19	14.78	6.92	51000	—	—	—	—	—
Maxim'm per day.											
Concentrated food	7.5	1.38	.49	4.32	.20	13050	—	—	—	—	—
Coarse food,	29.2	1.62	.71	11.95	7.49	42150	—	—	—	—	—
Total,	36.7	3.00	1.20	16.27	7.69	55200	—	—	—	—	—

TABLE 20.

Dairy Herd No. 7.—Statistics of Herd from Jan. 9 to 14, 1893.

Ref. No.	Breed.	Age.	Weight.	Months since Last Calf.	Milk Flow. Min. per Day.	Milk Flow. Max. per Day.	Milk Flow. Total in 5 Days.	Daily Percentage of Fat. Min.	Daily Percentage of Fat. Max.	Daily Percentage of Fat. Average.	Yield of Fat. Min. per Day.	Yield of Fat. Max. per Day.	Yield of Fat. Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Hol.,	7	850	7	21.6	22.9	**111.5**	4.3	4.5	**4.4**	.94	.99	**4.86**
2	G. Dev.,	8	900	4	25.0	26.2	**127.3**	3.5	4.3	**3.8**	.90	1.08	**4.84**
3	G. Hol.,	3	850	5	24.7	28.1	**131.3**	2.9	3.3	**3.0**	.72	8.7	**3.99**
4	G. Hol.,	4	825	2	21.3	24.0	**111.8**	4.0	4.3	**4.1**	.86	1.03	**4.57**
5	G. Jy.,	8	925	6	13.8	14.8	**70.6**	5.7	5.9	**5.8**	.80	.84	**4.07**
6	G. Jy.,	8	775	2	14.8	17.0	**81.2**	6.4	6.8	**6.6**	1.01	1.09	**5.36**
7	G. Jy.,	5	650	1	21.4	22.8	**109.7**	4.5	5.1	**4.8**	.98	1.16	**5.27**
8	G. Jy.,	5	750	9	18.3	18.9	**92.9**	4.7	5.3	**5.1**	.89	.99	**4.73**
9	G. Hol.,	7	925	5	23.2	24.2	**119.2**	4.3	5.0	**4.7**	1.00	1.19	**5.60**
10	G. Ay.,	7	850	6	15.6	16.7	**81.7**	4.4	4.8	**4.6**	.72	.79	**3.77**
11	G. Jy.,	2	700	3	25.9	27.2	**132.4**	3.4	3.5	**3.4**	.88	.95	**4.56**
12	G. Jy.,	5	850	9	13.3	14.3	**69.2**	6.3	6.8	**6.6**	.87	.94	**4.55**
13	Native,	9	825	4	20.2	22.5	**106.6**	3.3	4.5	**4.1**	.74	.96	**4.34**
14	G. Ay.,	8	800	8	16.9	17.7	**86.2**	5.4	6.1	**5.7**	.94	1.05	**4.96**
15	G. Hol.,	5	900	7	17.2	17.8	**85.2**	4.0	4.4	**4.2**	.69	.76	**3.59**
16	Native,	7	850	9	25.9	27.5	**132.7**	3.5	4.1	**3.8**	.92	1.06	**4.98**
17	Native,	7	850	9	16.5	17.3	**84.5**	3.9	5.3	**4.9**	.65	.89	**4.15**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Total Nutrients and Energy. Fat.	Total Nutrients and Energy. Nit.-free Ext.	Total Nutrients and Energy. Fiber.	Total Nutrients and Energy. Fuel Value (Energy).	Digested Nutrients and Energy. Protein.	Digested Nutrients and Energy. Fat.	Digested Nutrients and Energy. Carbohydrates.	Digested Nutrients and Energy. Nutritive Ratio.	Digested Nutrients and Energy. Fuel Value (Energy).
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Provender,*	8.5	.83	.38	5.95	.21	—	.54	.34	5.10	—	—
Wheat middlings,	5.6	1.14	.36	3.01	.30	—	.90	.31	2.60	—	—
Concentrated food	14.1	1.97	.74	8.96	.51	24400	1.44	.65	7.70	—	19740
Hay,	24.4	1.86	.81	11.23	5.87	38700	1.00	.44	10.30	—	22860
Total food,	**38.5**	**3.83**	**1.55**	**20.19**	**6.38**	**63100**	**2.44**	**1.09**	**18.00**	**8.4**	**42600**
Minimum per day.											
Concentrated food	13.8	1.93	.73	8.83	.50	24050	—	—	—	—	—
Coarse food,	23.9	1.82	.78	10.97	5.73	37750	—	—	—	—	—
Total,	37.7	3.75	1.51	19.80	6.23	61800	—	—	—	—	—
Maxim'm per day.											
Concentrated food	13.8	2.00	.75	8.99	.51	24500	—	—	—	—	—
Coarse food,	25.0	1.89	.82	11.48	6.00	39500	—	—	—	—	—
Total,	38.8	3.89	1.57	20.47	6.51	64000	—	—	—	—	—

* Said to be one-third oats and two-thirds corn.

TABLE 21.

Dairy Herd No. 8.—Statistics of Herd from Jan. 16 to 21, 1893.

Reference No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow. Min. per Day.	Milk Flow. Max. per Day.	Milk Flow. Total in 5 Days.	Daily Percentage of Fat. Minimum.	Daily Percentage of Fat. Maximum.	Daily Percentage of Fat. Average.	Yield of Fat. Min. per Day.	Yield of Fat. Max. per Day.	Yield of Fat. Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Gy.,	8	850	5	16.3	18.6	**87.6**	4.1	5.7	**4.9**	.72	1.03	**4.26**
2	R. Gy.,	4	750	3	14.1	16.0	**75.6**	4.9	5.6	**5.2**	.72	.86	**3.98**
3	R. Gy.,	4	600	4	11.7	14.0	**63.8**	4.7	5.6	**5.2**	.55	.72	**3.33**
4	R. Gy.,	3	700	11	6.8	8.0	**38.0**	4.3	6.0	**5.5**	.34	.48	**2.09**
5	R. Gy.,	2	525	0	17.7	18.6	**90.4**	4.3	5.2	**4.7**	.76	.95	**4.25**
6	G. Gy.,	5	750	2	24.1	26.0	**126.2**	4.0	4.3	**4.2**	.99	1.08	**5.26**
7	G. Gy.,	3	700	2	17.3	19.8	**93.4**	4.2	4.7	**4.5**	.81	.91	**4.22**
8	R. Gy.,	7	750	2	13.9	16.4	**78.3**	3.9	5.1	**4.5**	.63	.84	**3.49**
9	G. Gy.,	10	850	4	13.5	14.6	**69.6**	4.9	5.2	**5.0**	.62	.73	**3.42**
10	G. Gy.,	7	850	1	23.3	26.9	**124.8**	3.5	4.9	**4.2**	.98	1.20	**5.29**
11	G. Gy.,	5	700	2	15.1	17.0	**80.5**	4.5	5.0	**4.8**	.68	.83	**3.87**
12	Native,	13	900	2	24.1	26.2	**127.0**	4.2	4.5	**4.3**	1.04	1.16	**5.50**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Total. Fat.	Total. Nit.-free Ext.	Total. Fiber.	Total. Fuel Value (Energy).	Digested Nutrients and Energy. Protein.	Digested. Fat.	Digested. Carbohydrates.	Digested. Nutritive Ratio.	Digested. Fuel Value (Energy.)
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lb	Lbs.		Cal.
Grain,* - -	12.2	2.08	.64	6.47	1.23	20900	1.60	.50	5.35	—	15050
Hay, - - -	28.7	2.98	.79	11.75	7.74	45100	1.56	.43	11.60	—	26300
Total food, -	**40.9**	**5.06**	**1.43**	**18.22**	**8.97**	**66000**	**3.16**	**.93**	**16.95**	**6.0**	**41350**
Minimum per day.											
Concentrated food	11.8	2.02	.62	6.26	1.19	20250	—	—	—	—	—
Coarse food, -	23.5	2.44	.65	9.64	6.36	37050	—	—	—	—	—
Total, - -	35.3	4.46	1.27	15.90	7.55	57300	—	—	—	—	—
Maxim'm per day.											
Concentrated food	12.7	2.16	.66	6.73	1.28	21700	—	—	—	—	—
Coarse food, -	34.6	3.59	.95	14.17	9.34	54400	—	—	—	—	—
Total, - -	47.3	5.75	1.61	20.90	10.62	76100	—	—	—	—	—

* Grain consisted of: Wheat bran, 200 lbs.; cob meal, 300 lbs.

TABLE 22.

Dairy Herd No. 9.—Statistics of Herd from Jan. 23 to 28, 1893.

Reference No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow. Min. per day.	Milk Flow. Max. per day.	Milk Flow. Total in 5 Days.	Daily Percentage of Fat. Min.	Daily Percentage of Fat. Max.	Daily Percentage of Fat. Average.	Yield of Fat. Min. per day.	Yield of Fat. Max. per day.	Yield of Fat. Total in 5 days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	R. Gy.,	11	925	4	16.0	16.8	**82.7**	4.3	4.5	**4.4**	.72	.76	**3.66**
2	G. Gy.,	9	900	3	23.0	24.1	**117.4**	3.5	4.1	**3.8**	.82	.99	**4.51**
3	G. Gy.,	10	900	3	17.5	19.4	**93.9**	4.4	4.6	**4.5**	.81	.89	**4.26**
4	R. Gy.,	8	925	2	18.9	19.5	**96.4**	5.2	5.6	**5.3**	.99	1.09	**5.16**
5	Native,	13	1000	10	16.0	18.5	**85.6**	4.4	4.5	**4.4**	.72	.83	**3.80**
6	R. Gy.,	4	800	2	13.9	15.0	**71.7**	3.8	4.1	**4.0**	.54	.60	**2.86**
7	R. Gy.,	5	850	2	10.3	11.0	**53.0**	5.4	5.8	**5.5**	.56	.61	**2.93**
8	G. Gy.,	6	800	10	12.1	12.8	**62.3**	5.0	5.4	**5.2**	.62	.69	**3.26**
9	G. Gy.,	4	925	8	13.7	15.0	**71.7**	4.6	5.0	**4.9**	.65	.74	**3.50**
10	G. Gy.,	5	900	4	5.1	5.9	**28.4**	4.8	5.2	**4.9**	.26	.30	**1.41**
11	R. Gy.,	6	825	3	10.6	11.3	**54.8**	4.4	5.5	**4.9**	.49	.61	**2.71**
12	G. Gy.,	5	900	3	15.9	17.8	**84.5**	4.9	5.6	**5.1**	.80	.97	**4.34**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Total Nutrients and Energy. Fat.	Total Nutrients and Energy. Nit.-free Ext.	Total Nutrients and Energy. Fiber.	Total Nutrients and Energy. Fuel Value (Energy).	Digested Nutrients and Energy. Protein.	Digested Nutrients and Energy. Fat.	Digested Nutrients and Energy. Carbohydrates.	Digested Nutrients and Energy. Nutritive Ratio.	Digested Nutrients and Energy. Fuel Value (Energy).
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Grain,* - -	7.4	1.62	.65	3.81	.22	13240	1.20	.58	3.14	—	10500
Hay, - - -	12.0	.72	.24	4.75	3.16	—	.39	.13	4.73	—	—
Rowen, - -	5.1	.64	.18	1.78	1.08	—	.40	.08	1.89	—	—
Stover, - -	5.1	.32	.07	2.15	1.38	—	.17	.04	2.29	—	—
Total coarse food,	22.2	1.68	.49	8.68	5.62	31760	.96	.25	8.91	—	19450
Total food, -	**29.6**	**3.30**	**1.14**	**12.49**	**5.84**	**45000**	**2.16**	**.83**	**12.05**	**6.4**	**29950**
Minimum per day.											
Concentrated food	6.6	1.46	.58	3.43	.20	11900	—	—	—	—	—
Coarse food, -	20.1	1.56	.46	7.85	5.08	28900	—	—	—	—	—
Total, - -	26.7	3.02	1.04	11.28	5.28	40800	—	—	—	—	—
Maxim'm per day.											
Concentrated food	7.7	1.68	.67	3.95	.23	13700	—	—	—	—	—
Coarse food, -	23.4	1.77	.51	9.22	5.97	33700	—	—	—	—	—
Total, - -	31.1	3.45	1.18	13.17	6.20	47400	—	—	—	—	—

*Grain mixture consisted of 300 lbs. corn meal, 150 lbs. wheat bran, 150 lbs. cotton seed meal, and 150 lbs. cream gluten.

TABLE 23.

Dairy Herd No. 10.–Statistics of Herd from Jan. 30 to Feb. 4, 1893.

Ref. No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow.			Daily Percentage of Fat.			Yield of Fat.		
					Min. per day.	Max. per day.	Total in 5 Days.	Min.	Max.	Average.	Min. per day.	Max. per day.	Total in 5 days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Jy.,	7	825	9	11.5	13.2	**62.5**	4.9	5.5	**5.3**	.62	.71	**3.32**
2	G. Jy.,	8	875	7	12.2	13.7	**65.7**	5.9	6.2	**6.1**	.74	.84	**3.99**
3	G. Jy.,	6	875	–	14.3	15.7	**75.8**	4.2	4.6	**4.4**	.63	.70	**3.33**
4	G. Jy.,	3	800	0	15.0	17.4	**78.5**	4.7	5.6	**5.1**	.71	.89	**3.97**
5	P. Jy.,	8	925	0	25.9	28.2	**135.1**	4.7	5.3	**5.0**	1.26	1.41	**6.72**
6	G. Jy.,	4	800	4	17.4	18.5	**90.2**	4.0	4.4	**4.3**	.74	.80	**3.85**
7	G. Jy.,	6	975	0	36.8	38.8	**189.5**	3.8	4.2	**3.9**	1.44	1.55	**7.39**
8	G. Dev.	8	900	1	21.6	23.1	**112.6**	3.9	4.5	**4.2**	.90	1.04	**4.73**
9	G. Jy.,	5	875	0	26.6	28.5	**137.9**	4.8	5.4	**5.1**	1.38	1.49	**7.07**
10	G. Jy.,	5	850	2	21.9	24.3	**116.5**	4.7	5.3	**4.9**	1.05	1.19	**5.70**
11	G. Jy.,	5	825	2	19.4	20.6	**100.5**	4.0	4.3	**4.1**	.80	.89	**4.15**
12	G. Jy.,	3	775	4	9.1	13.2	**59.1**	5.9	6.6	**6.1**	.60	.79	**3.60**
13	R. Jy.,	3	800	3	13.3	15.9	**76.2**	4.9	6.5	**5.5**	.77	.86	**4.12**
14	R. Jy.,	3	825	0	30.7	34.9	**163.5**	3.5	3.6	**3.5**	1.10	1.22	**5.76**
15	R. Jy.,	2	800	2	12.3	15.2	**71.8**	3.9	4.4	**4.1**	.54	.65	**2.97**
16	G. Jy.,	5	850	0	25.9	28.1	**136.2**	4.5	5.1	**4.7**	1.19	1.38	**6.42**
17	G. Jy.,	6	800	4	17.9	19.0	**91.5**	4.5	5.1	**4.8**	.81	.91	**4.38**
18	G. Jy.,	6	825	4	19.3	19.8	**98.1**	4.5	4.6	**4.6**	.89	.91	**4.48**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy.					Digested Nutrients and Energy.				
		Protein.	Fat.	Nit.-free Ext.	Fiber.	Fuel Val. (En'gy).	Protein.	Fat.	Carbo-hydrates.	Nutritive Ratio.	Fuel Val. (En'gy).
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Grain,*	8.2	1.57	.55	4.62	.27	14300	1.09	.50	3.72	—	11100
Stover,	6.9	.33	.14	2.85	1.92	—	.17	.08	3.09	—	—
Rowen,	10.2	1.31	.35	4.05	2.25	—	.81	.16	4.15	—	—
Hay,	5.2	.47	.18	2.26	1.30	—	.25	.10	2.08	—	—
Total coarse food,	22.3	2.11	.67	9.16	5.47	34000	1.23	.34	9.32	—	21000
Total food,	**30.5**	**3.68**	**1.22**	**13.78**	**5.74**	**48300**	**2.32**	**8.4**	**13.04**	**6.4**	**32100**
Minimum per day.											
Concentrated food	8.1	1.56	.55	4.60	.27	14200	—	—	—	—	—
Coarse food,	20.6	1.96	.61	8.44	5.01	31200	—	—	—	—	—
Total,	28.7	3.52	1.16	13.04	5.28	45400	—	—	—	—	—
Maxim'm per day.											
Concentrated food	8.0	1.54	.54	4.52	.26	14050	—	—	—	—	—
Coarse food,	26.4	2.50	.79	10.85	6.43	40150	—	—	—	—	—
Total,	34.4	4.04	1.33	15.37	6.69	54200	—	—	—	—	—

*Grain mixtures consisted of 600 lbs. corn meal, 300 lbs. cotton seed meal, and 170 lbs. wheat bran.

TABLE 24.

Dairy Herd No. 11.—Statistics of Herd from Feb. 6 to 11, 1893.

Ref. No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow. Min. per Day.	Milk Flow. Max. per Day.	Milk Flow. Total in 5 Days.	Daily Percentage of Fat. Min.	Daily Percentage of Fat. Max.	Daily Percentage of Fat. Average.	Yield of Fat. Min. per Day.	Yield of Fat. Max. per Day.	Yield of Fat. Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Jy.,	3	875	5	15.9	19.9	**89.3**	4.8	5.6	**5.2**	.89	.96	**4.67**
2	G. Jy.,	4	850	5	14.8	17.2	**80.1**	5.5	5.8	**5.7**	.86	.95	**4.57**
3	G. Jy.,	5	875	5	16.7	20.3	**93.8**	4.3	4.7	**4.5**	.79	.87	**4.23**
4	G. Jy.,	4	850	5	18.1	19.1	**92.6**	4.4	5.0	**4.8**	.80	.95	**4.50**
5	G. Jy.,	4	900	5	18.9	21.5	**101.8**	4.7	5.1	**4.9**	.95	1.03	**4.93**
6	G. Jy.,	3	825	5	13.3	16.6	**77.2**	4.2	4.7	**4.4**	.63	.71	**3.39**
7	G. Jy.,	3	850	5	12.0	13.8	**66.0**	4.2	4.7	**4.4**	.55	.61	**2.89**
8	G. Jy.,	7	825	5	16.0	18.2	**86.1**	5.2	5.9	**5.6**	.93	1.01	**4.79**
9	G. Jy.,	4	850	5	17.2	18.8	**91.2**	5.6	6.2	**6.0**	1.04	1.15	**5.46**
10	G. Jy.,	10	1050	5	12.0	14.0	**65.6**	4.3	5.2	**4.7**	.58	.65	**3.09**
11	G. Jy.,	4	800	5	13.7	15.6	**73.9**	5.3	5.7	**5.5**	.77	.84	**4.05**
12	G. Jy.,	4	800	5	6.2	6.7	**31.9**	4.5	5.6	**4.8**	.29	.35	**1.53**
13	G. Jy.,	4	850	5	17.6	19.5	**93.5**	4.2	4.9	**4.5**	.82	.88	**4.24**
14	G. Jy.,	8	900	5	12.5	15.5	**69.8**	4.7	5.6	**5.2**	.70	.75	**3.63**
15	G. Jy.,	8	925	5	16.2	18.5	**88.5**	4.8	5.3	**5.0**	.79	.97	**4.43**
16	G. Jy.,	2	825	5	12.0	13.9	**62.6**	4.8	5.3	**5.0**	.57	.69	**3.16**
17	G. Jy.,	2	875	5	12.0	13.3	**63.7**	4.1	4.6	**4.4**	.49	.59	**2.80**
18	G. Jy.,	2	875	5	13.9	16.9	**76.4**	4.1	4.4	**4.3**	.60	.70	**3.28**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Total Nutrients and Energy. Fat.	Total Nutrients and Energy. N.-free Ext.	Total Nutrients and Energy. Fiber.	Total Nutrients and Energy. F. Val. (En'gy)	Digested Nutrients and Energy. Protein.	Digested Nutrients and Energy. Fat.	Digested Nutrients and Energy. Carbo-hyd's.	Digested Nutrients and Energy. Nu. Ratio.	Digested Nutrients and Energy. F. Val. (En'gy)
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Grain,* - -	10.2	2.51	.78	5.20	.43	18400	1.91	.70	4.17	—	14250
Hay, - -	12.1	.83	.28	4.61	4.21	—	.45	.15	5.22	—	—
Oat hay, - -	6.7	.57	.22	2.85	1.01	—	.31	.12	2.35	—	—
Stover, - -	3.8	.18	.07	1.52	1.13	—	.09	.04	1.72	—	—
Total coarse food,	22.6	1.58	.57	8.98	6.35	33900	.85	.31	9.29	—	20200
Total food, -	**32.8**	**4.09**	**1.35**	**14.18**	**6.78**	**52300**	**2.76**	**1.01**	**13.46**	**5.7**	**34450**
Minimum per day.											
Concentrated food,	10.4	2.53	.79	5.35	.44	18800	—	—	—	—	—
Coarse food, -	19.9	1.39	.50	7.93	5.61	29900	—	—	—	—	—
Total, - -	30.3	3.92	1.29	13.28	6.05	48700	—	—	—	—	—
Maxim'm per day.											
Concentrated food,	10.2	2.64	.80	5.11	.42	18550	—	—	—	—	—
Coarse food, -	23.8	1.64	.59	9.43	6.82	35750	—	—	—	—	—
Total, - -	34.0	4.28	1.39	14.54	7.24	54300	—	—	—	—	—

* Grain mixture consisted of 200 lbs. wheat middlings, 200 lbs. corn meal, 200 lbs. cotton seed meal, 50 lbs. wheat bran.

TABLE 25.

Dairy Herd No. 12.—Statistics of Herd from Feb. 13 to 18, 1893.

Ref. No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow. Min. per Day.	Milk Flow. Max. per Day.	Milk Flow. Total in 5 Days.	Daily Percentage of Fat. Min.	Daily Percentage of Fat. Max.	Daily Percentage of Fat. Average.	Yield of Fat. Min. per Day.	Yield of Fat. Max. per Day.	Yield of Fat. Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	Native,	3	850	2	24.1	26.0	**124.0**	3.9	5.2	**4.6**	.90	1.31	**5.69**
2	Native,	6	875	2	31.3	32.8	**160.9**	3.8	4.4	**4.0**	1.19	1.44	**6.47**
3	G. Jy.,	4	850	11	13.8	14.6	**70.5**	4.8	5.4	**5.1**	.66	.75	**3.61**
4	R. Jy.,	4	775	6	16.2	18.7	**85.1**	4.7	5.9	**5.1**	.78	1.10	**4.38**
5	G. Jy.,	3	800	13	14.0	15.3	**73.5**	6.2	6.9	**6.5**	.90	1.00	**4.78**
6	G. Jy.,	9	850	13	14.1	15.3	**73.9**	5.3	5.5	**5.4**	.75	.84	**3.94**
7	G. Jy.,	6	825	2	27.8	29.4	**143.0**	4.4	4.9	**4.7**	1.25	1.40	**6.66**
8	Native,	8	850	1	40.0	41.3	**203.6**	3.6	4.3	**4.0**	1.49	1.72	**8,06**
9	Native,	5	875	6	21.8	26.8	**117.2**	3.8	5.2	**4.6**	.83	1.26	**5.40**
10	R. Hol.,	2	750	6	19.2	22.8	**104.6**	3.0	3.4	**3.2**	.63	.69	**3.32**
11	Native,	3	825	13	11.2	11.9	**57.1**	4.5	5.2	**4.9**	.54	.58	**2.81**
12	Native,	6	875	9	10.6	11.6	**54.4**	4.1	4.5	**4.3**	.44	.49	**2.33**
13	G. Jy.,	8	925	11	14.7	16.0	**76.7**	4.5	4.9	**4.7**	.69	.75	**3.58**
14	G. Jy.,	6	850	13	22.9	27.5	**124.4**	4.6	5.2	**4.9**	1.10	1.43	**6.14**
15	R. Hol.,	8	1100	8	30.6	31.9	**156.0**	3.2	3.5	**3.3**	.98	1.12	**5.15**
16	G. Jy.,	6	850	4	16.4	18.0	**86.6**	4.3	4.5	**4.4**	.72	.78	**3.78**
17	R. Hol.,	4	1025	6	24.3	26.1	**126.3**	3.0	4.1	**3.6**	.76	1.02	**4.59**
18	G. Jy.,	8	800	10	9.3	12.6	**53.0**	4.3	4.8	**4.6**	.44	.61	**2.45**
19	Native,	8	1100	4	20.0	21.4	**103.0**	3.2	4.2	**3.9**	.68	.87	**3.98**
20	G. Jy.,	5	875	3	29.2	33.1	**155.8**	4.0	4.2	**4.1**	1.17	1.39	**6.36**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Total Nutrients and Energy. Fat.	Total Nutrients and Energy. N.-free Ext.	Total Nutrients and Energy. Fiber.	Total Nutrients and Energy. F. Val. (En'gy)	Digested Nutrients and Energy. Protein.	Digested Nutrients and Energy. Fat.	Digested Nutrients and Energy. Carbohyd's.	Digested Nutrients and Energy. Nu. Ratio.	Digested Nutrients and Energy. F. Val. (En'gy)
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Wheat bran, -	3.8	.56	.21	2.11	.35	—	.44	.15	1.48	—	—
Grain,* - -	4.7	1.25	.36	2.27	.12	—	.93	.35	1.80	—	—
Malt sprouts, -	4.6	1.15	.09	2.02	.56	—	.92	.06	1.56	—	—
Total concentrated food, - -	13.1	2.96	.66	6.40	1.03	22100	2.29	.56	4.84	—	15650
Ensilage, - -	41.1	.71	.29	3.12	2.18	—	.33	.23	3.55	—	—
Hay, - - -	7.4	.69	.28	3.26	1.77	—	.37	.15	3.02	—	—
Total coarse food,	48.5	1.40	.57	6.38	3.95	24200	.70	.38	6.57	—	15100
Total food, -	**61.6**	**4.36**	**1.23**	**12.78**	**4.98**	**46300**	**2.99**	**.94**	**11.41**	**4.5**	**30750**
Minimum per day.											
Concentrated food	12.7	2.91	.64	6.28	1.03	21700	—	—	—	—	—
Coarse food, -	48.2	1.37	.55	6.21	3.86	23600	—	—	—	—	—
Total, - -	60.9	4.28	1.19	12.49	4.89	45300	—	—	—	—	—
Maxim'm per day.											
Concentrated food	13.3	2.98	.67	6.57	1.08	22600	—	—	—	—	—
Coarse food, -	50.3	1.56	.63	7.19	4.39	27100	—	—	—	—	—
Total, - -	63.6	4.54	1.30	13.76	5.47	49700	—	—	—	—	—

* Grain mixture consisted of equal parts, by weight, of corn meal and cotton seed meal.

TABLE 26.

Dairy Herd No. 13.—Statistics of Herd from Feb. 27 to Mar. 4, 1893.

Reference No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow. Min. per Day.	Milk Flow. Max. per Day.	Milk Flow. Total in 5 Days.	Daily Percentage of Fat. Min.	Daily Percentage of Fat. Max.	Daily Percentage of Fat. Average.	Yield of Fat. Min. per Day.	Yield of Fat. Max. per Day.	Yield of Fat. Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	P. Jy.,	3	750	10	12.6	13.5	**65.2**	4.5	5.1	**4.9**	.58	.69	**3.20**
2	P. Jy.,	2	700	5	16.0	17.4	**83.6**	4.1	4.7	**4.4**	.66	.82	**3.68**
3	G. Jy.,	3	700	12	11.6	12.7	**60.8**	4.4	4.6	**4.5**	.53	.59	**2.77**
4	G. Jy.,	3	700	3	20.9	21.7	**107.2**	3.8	4.6	**4.2**	.83	1.00	**4.47**
5	P. Jy.,	3	700	9	11.8	12.6	**60.9**	4.1	4.9	**4.5**	.49	.60	**2.75**
6	P. Jy.,	3	700	10	12.6	14.4	**67.7**	4.9	5.3	**5.1**	.66	.71	**3.45**
7	P. Jy.,	2	700	7	12.5	13.2	**63.7**	5.0	6.0	**5.5**	.63	.77	**3.53**
8	G. Jy.,	7	725	10	8.1	8.6	**41.2**	4.7	5.0	**4.8**	.38	.43	**1.98**
9	R. Jy.,	10	850	10	10.5	11.1	**53.9**	5.2	6.0	**5.6**	.58	.65	**3.01**
10	G. Hol.,	10	850	2	20.8	23.1	**109.8**	3.2	3.7	**3.4**	.67	.84	**3.73**
11	G. Dev.,	10	850	14	6.5	7.5	**36.0**	5.4	5.9	**5.6**	.35	.44	**2.01**
12	G. Jy.,	4	825	1	20.0	21.3	**104.2**	3.9	4.3	**4.1**	.80	.91	**4.29**
13	G. Dev.,	7	875	26	11.0	13.5	**58.3**	3.8	4.3	**4.1**	.43	.51	**2.36**
14	G. Ay.,	5	850	12	6.9	9.2	**39.0**	4.8	5.1	**4.9**	.35	.44	**1.90**
15	G. Jy.,	6	850	7	10.9	12.8	**58.0**	4.9	5.3	**5.0**	.54	.64	**2.92**
16	G. Gy.,	7	850	8	8.7	11.5	**48.6**	5.0	5.5	**5.3**	.44	.59	**2.57**
17	Native,	6	925	14	11.1	12.2	**58.4**	4.0	4.9	**4.3**	.46	.60	**2.50**
18	G. Dev.,	10	875	12	10.2	12.1	**56.3**	4.9	5.4	**5.1**	.53	.63	**2.87**
19	G. Jy.,	3	775	10	7.0	.83	**37.6**	5.5	5.9	**5.7**	.39	.48	**2.16**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Total Nutrients and Energy. Fat.	Total Nutrients and Energy. Nit.-free Ext.	Total Nutrients and Energy. Fiber.	Total Nutrients and Energy. Fuel Value (Energy).	Digested Nutrients and Energy. Protein.	Digested Nutrients and Energy. Fat.	Digested Nutrients and Energy. Carbohydrates.	Digested Nutrients and Energy. Nutritive Ratio.	Digested Nutrients and Energy. Fuel Value (Energy).
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Grain,* - -	11.2	2.25	.72	6.13	.56	19600	1.67	.64	5.27	—	15600
Ensilage, - -	30.7	.33	.20	2.69	1.39	—	.15	.16	2.73	—	—
Hay, - - -	7.5	.70	.22	3.28	1.99	—	.38	.12	3.17	—	—
Total coarse food,	38.2	1.03	.42	5.97	3.38	21100	.53	.28	5.90	—	13150
Total food, -	**49.4**	**3.28**	**1.14**	**12.10**	**3.94**	**40700**	**2.20**	**.92**	**11.17**	**6.0**	**28750**
Minimum per day.											
Concentrated food,	11.0	2.23	.72	6.08	.55	19500	—	—	—	—	—
Coarse food, -	37.0	1.01	.41	5.80	3.29	20500	—	—	—	—	—
Total, - -	48.0	3.24	1.13	11.88	3.84	40000	—	—	—	—	—
Maxim'm per day.											
Concentrated food,	11.1	2.26	.72	6.15	.57	19800	—	—	—	—	—
Coarse food, -	40.1	1.05	.43	6.15	3.47	21600	—	—	—	—	—
Total, - -	51.2	3.31	1.15	12.30	4.04	41400	—	—	—	—	—

* Grain mixture consisted of 50 lbs. cotton seed meal, 200 lbs. wheat middlings, and 100 lbs. corn meal.

TABLE 27.

Dairy Herd No. 14.—Statistics of Herd from March 6 to 11, 1893.

Reference No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow.			Daily Percentage of Fat.			Yield of Fat.		
					Min. per Day.	Max. per Day.	Total in 5 Days.	Min.	Max.	Average.	Min. per Day.	Max. per Day.	Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Jy.,	2	800	3	19.8	20.8	**81.8**	4.8	4.9	**4.8**	.95	1.02	**3.95**
2	G. Jy.,	2	800	2	21.1	22.9	**88.2**	5.1	5.9	**5.3**	1.10	1.27	**4.75**
3	G. Jy.,	2	775	3	21.6	22.9	**89.1**	4.9	5.2	**5.0**	1.07	1.19	**4.52**
4	G. Jy.,	6	825	5	16.1	17.1	**66.6**	5.1	5.5	**5.4**	.82	.94	**3.58**
5	G. Jy.,	8	850	11	10.1	11.7	**43.1**	6.3	6.5	**6.4**	.64	.76	**2.75**
6	G. Jy.,	10	850	5	19.6	20.8	**81.6**	4.7	4.9	**4.9**	.96	1.02	**3.96**
7	G. Jy.,	9	900	3	29.3	34.2	**127.3**	3.6	4.7	**4.0**	1.10	1.40	**5.12**
8	G. Jy.,	9	950	3	28.4	31.3	**118.7**	4.2	5.1	**4.5**	1.22	1.52	**5.43**
9	G. Jy.,	8	950	1	34.0	36.9	**139.5**	4.9	5.1	**5.0**	1.67	1.88	**6.98**
10	G. Jy.,	17	950	5	19.9	23.0	**87.7**	3.7	4.2	**3.9**	.74	.96	**3.38**

Pounds of Food and Nutrients per day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy.					Digested Nutrients and Energy.				
		Protein.	Fat.	Nit.-free Ext.	Fiber.	Fuel Val. (En'gy).	Protein.	Fat.	Carbohydrates.	Nutritive Ratio.	Fuel Val. (En'gy).
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Grain,* - -	9.4	2.23	.85	4.95	.38	17690	1.71	.64	3.79	—	12900
Hay, - - -	18.7	1.60	.68	8.00	4.33	—	.86	.37	7.42	—	—
Stover, - -	3.6	.17	.08	1.77	1.14	—	.09	.04	1.88	—	—
Total coarse food,	22.3	1.77	.76	9.77	5.47	34810	.95	.41	9.30	—	20850
Total food, -	**31.7**	**4.00**	**1.61**	**14.72**	**5.85**	**52500**	**2.66**	**1.05**	**13.09**	**5.8**	**33750**
Minimum per day.											
Concentrated food	9.4	2.22	.85	4.92	.38	17600	—	—	—	—	—
Coarse food, -	20.2	1.61	.68	8.86	4.97	31600	—	—	—	—	—
Total, - -	29.6	3.83	1.53	13.78	5.35	49200	—	—	—	—	—
Maxim'm per day.											
Concentrated food	9.7	2.30	.87	5.10	.40	18200	—	—	—	—	—
Coarse food, -	22.9	1.82	.79	10.01	5.59	35700	—	—	—	—	—
Total, - -	32.6	4.12	1.66	15.11	5.99	53900	—	—	—	—	—

* Grain mixture consisted of 100 lbs. gluten meal, 100 lbs. oat feed, 100 lbs. wheat bran.

TABLE 28.

Dairy Herd No. 15.—Statistics of Herd from March 13 to 18, 1893.

Ref. No.	Breed.	Age.	Weight.	Months Since Last Calf.	Milk Flow. Min. per Day.	Milk Flow. Max. per Day.	Milk Flow. Total in 5 Days.	Daily Percentage of Fat. Min.	Daily Percentage of Fat. Max.	Daily Percentage of Fat. Average.	Yield of Fat. Min. per Day.	Yield of Fat. Max. per Day.	Yield of Fat. Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Jy.,	6	850	1	18.4	19.2	**93.6**	4.0	4.5	**4.3**	.73	.86	**4.04**
2	G. Jy.,	5	825	7	10.6	11.6	**56.4**	3.4	3.8	**3.6**	.36	.43	**2.04**
3	G. Jy.,	5	850	4	13.6	14.7	**70.0**	5.4	5.8	**5.6**	.75	.85	**3.95**
4	G. Ay.,	5	875	1	20.3	21.5	**105.2**	3.5	4.0	**3.8**	.75	.81	**3.94**
5	G. Jy.,	5	850	2	18.8	20.8	**99.0**	4.1	4.9	**4.6**	.85	.98	**4.52**
6	G. Jy.,	9	850	6	13.2	14.2	**68.8**	5.3	5.7	**5.5**	.73	.79	**3.78**
7	G. Jy.,	5	800	2	9.7	10.7	**50.1**	7.5	7.7	**7.6**	.74	.82	**3.82**
8	G. Jy.,	9	860	6	12.8	13.3	**65.1**	4.9	5.3	**5.1**	.65	.68	**3.31**
9	G. Jy.,	9	875	7	11.3	12.5	**59.0**	5.9	6.3	**6.1**	.68	.79	**3.61**
10	G. Jy.,	5	875	6	10.3	12.4	**57.8**	5.2	6.6	**5.7**	.57	.82	**3.34**
11	G. Jy.,	4	850	5	12.1	12.6	**61.5**	4.6	5.0	**4.8**	.57	.62	**2.98**
12	G. Jy.,	5	875	5	13.1	13.7	**67.2**	4.8	5.3	**5.0**	.63	.71	**3.37**
13	G. Jy.,	4	875	3	12.7	13.9	**66.2**	4.7	5.3	**5.0**	.60	.70	**3.28**
14	G. Jy.,	8	850	2	18.6	21.3	**99.2**	3.2	3.7	**3.4**	.65	.70	**3.39**
15	G. Jy.,	8	825	8	11.0	11.4	**56.3**	5.0	5.5	**5.3**	.57	.62	**2.97**
16	G. Jy.,	4	825	8	9.4	9.8	**48.0**	5.6	6.0	**5.7**	.53	.60	**2.81**
17	G. Jy.,	4	835	7	12.3	13.1	**63.9**	4.2	4.8	**4.5**	.52	.61	**2.87**
18	G. Jy.,	4	800	7	10.8	11.8	**55.2**	4.6	5.4	**4.9**	.50	.59	**2.73**
19	G. Jy.,	4	800	7	9.2	10.0	**48.0**	5.4	5.9	**5.7**	.50	.57	**2.71**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

Kinds of Feed.	Average Fed per Day.	Total Nutrients and Energy. Protein.	Total. Fat.	Total. Nit.-free Ext.	Total. Fiber.	Total. Fuel Val. (En'gy).	Digested Nutrients and Energy. Protein.	Digested. Fat.	Digested. Carbohydrates.	Digested. Nutritive Ratio.	Digested. Fuel Val. (En'gy).
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.	—	Cal.
Grain,* - -	8.8	.92	.46	5.82	.28	15000	.70	.37	4.79	—	11800
Fodder,† - -	14.9	.81	.26	6.67	4.14	—	.43	.14	6.80	—	—
Hay, - - -	5.4	.40	.10	2.57	1.41	—	.22	.05	2.40	—	—
Total coarse food,	20.3	1.21	.36	9.24	5.55	31300	.65	.19	9.20	—	19100
Total food, -	**29.1**	**2.13**	**.82**	**15.06**	**5.83**	**46300**	**1.35**	**.56**	**13.99**	**11.3**	**30900**
Minimum per day.											
Concentrated food	8.0	.83	.41	5.33	.26	13650	—	—	—	—	—
Coarse food, -	17.3	1.02	.31	7.86	4.74	26650	—	—	—	—	—
Total, - -	25.3	1.85	.72	13.19	5.00	40300	—	—	—	—	—
Maxim'm per day.											
Concentrated food	9.5	.98	.48	6.29	.30	16100	—	—	—	—	—
Coarse food, -	23.2	1.57	.46	10.87	6.22	36700	—	—	—	—	—
Total, - -	32.7	2.55	.94	17.16	6.52	52800	—	—	—	—	—

* Grain mixture consisted of 1000 lbs. cob meal, 175 lbs. rye meal, 150 lbs. wheat bran, 100 lbs. oat feed, and 100 lbs. O. P. linseed.

† Fodder consisted of 300 lbs. hay, and 400 lbs. stover.

TABLE 29.

Dairy Herd No. 16.—Statistics of Herd, March. 20 to 25, 1893.

Reference No.	Breed.	Age.	Weight.	Months Since Last Calf.	MILK FLOW. Minimum per Day.	MILK FLOW. Maximum per Day.	MILK FLOW. Total in 5 Days.	DAILY PERCENTAGE OF FAT. Minimum.	DAILY PERCENTAGE OF FAT. Maximum.	DAILY PERCENTAGE OF FAT. Average.	YIELD OF FAT. Minimum per Day.	YIELD OF FAT. Maximum per Day.	YIELD OF FAT. Total in 5 Days.
		Yrs.	Lbs.	Mo.	Lbs.	Lbs.	Lbs.	%	%	%	Lbs.	Lbs.	Lbs.
1	G. Dev.	7	1050	7	16.9	18.6	**87.8**	3.8	4.3	**4.0**	.66	.75	**3.55**
2	G. Dev.	5	1000	7	11.0	12.5	**57.6**	3.9	5.2	**4.4**	.44	.58	**2.56**
3	G. Dev.	5	900	7	14.1	16.4	**75.5**	4.2	4.8	**4.6**	.59	.78	**3.44**
4	G. Jy.	12	1100	7	18.6	20.0	**96.8**	4.3	4.7	**4.5**	.84	.92	**4.38**
5	G. Dev.	5	1035	7	14.6	15.4	**74.7**	4.1	4.5	**4.2**	.61	.67	**3.16**
6	Native,	4	850	6	14.8	18.2	**78.2**	4.4	4.8	**4.7**	.71	.80	**3.64**
7	G. Dev.	7	875	7	20.0	21.7	**103.9**	4.2	4.7	**4.5**	.84	.98	**4.67**
8	G. Dev.	7	875	7	12.0	12.9	**61.7**	4.2	4.9	**4.5**	.52	.63	**2.79**
9	G. Gy.	4	875	10	14.6	15.3	**75.7**	4.3	5.1	**4.8**	.66	.78	**3.60**
10	G. Dev.	4	875	7	12.9	13.5	**65.7**	4.2	4.8	**4.4**	.54	.65	**2.90**
11	Native,	5	850	8	26.1	28.3	**134.4**	4.4	4.8	**4.5**	1.15	1.29	**6.10**
12	G. Jy.	7	825	6	13.5	15.0	**70.3**	5.6	5.9	**5.7**	.77	.87	**4.05**
13	Native,	5	775	9	13.4	13.9	**68.0**	4.0	4.8	**4.5**	.55	.65	**3.06**
14	G. Jy.	8	800	11	14.2	16.0	**75.5**	4.9	5.9	**5.3**	.70	.88	**3.98**
15	G. Hol.,	6	940	3	23.5	24.2	**119.6**	3.5	4.1	**3.7**	.82	.99	**4.44**
16	G. Jy.	5	850	4	14.8	15.2	**75.0**	4.2	5.4	**5.0**	.63	.81	**3.74**
17	G. Gy.	3	825	4	17.3	18.8	**88.9**	4.1	4.7	**4.5**	.71	.88	**3.97**
18	G. Gy.	5	850	6	13.7	14.4	**70.8**	5.3	5.8	**5.6**	.73	.83	**3.94**
19	Native,	3	800	12	6.9	7.7	**36.3**	4.7	5.4	**4.9**	.32	.40	**1.80**
20	Native,	9	850	6	18.1	19.7	**94.1**	4.2	4.5	**4.4**	.78	.89	**4.17**

Pounds of Food and Nutrients per Day per 1000 Lbs., Live Weight.

KINDS OF FEED.	Average Fed per Day.	TOTAL NUTRIENTS AND ENERGY. Protein.	TOTAL NUTRIENTS AND ENERGY. Fat.	TOTAL NUTRIENTS AND ENERGY. Nit.-free Ext.	TOTAL NUTRIENTS AND ENERGY. Fiber.	TOTAL NUTRIENTS AND ENERGY. Fuel Val. (En'gy.)	DIGESTED NUTRIENTS AND ENERGY. Protein.	DIGESTED NUTRIENTS AND ENERGY. Fat.	DIGESTED NUTRIENTS AND ENERGY. Carbohydrates.	DIGESTED NUTRIENTS AND ENERGY. Nutritive Ratio.	DIGESTED NUTRIENTS AND ENERGY. Fuel Val. (En'gy.)
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
Corn meal, -	3.1	.26	.14	2.17	.05	—	.15	.13	1.92	—	—
Wheat bran, -	1.7	.31	.09	.92	.11	—	.24	.07	.65	—	—
Gluten meal, -	2.1	.25	.30	1.24	.12	—	.22	.26	1.17	—	—
Total concentrated food, - -	6.9	.82	.53	4.33	.28	12340	.61	.46	3.74	—	10100
Fodder,* - -	7.5	.52	.19	3.15	1.78	—	.28	.10	3.05	—	—
Hay, - -	14.2	1.02	.44	6.41	3.32	—	.55	.24	5.87	—	—
Total coarse food,	21.7	1.54	.63	9.56	5.10	32760	.83	.34	8.92	—	19500
Total food, -	**28.6**	**2.36**	**1.16**	**13.89**	**5.38**	**45100**	**1.44**	**.80**	**12.66**	**9.3**	**29600**
Minimum per day.											
Concentrated food	7.0	.83	.54	4.38	.27	12450	—	—	—	—	—
Coarse food, -	18.3	1.29	.52	7.99	4.31	27450	—	—	—	—	—
Total, - -	25.3	2.12	1.06	12.37	4.58	39900	—	—	—	—	—
Maxim'm per day.											
Concentrated food	7.2	.83	.54	4.46	.28	12600	—	—	—	—	—
Coarse food -	23.3	1.66	.69	10.35	5.50	35500	—	—	—	—	—
Total, - -	30.5	2.49	1.23	14.81	5.78	48100	—	—	—	—	—

* Fodder consisted of equal parts of poor hay and stover.

TABLE 30.

Summary of Total and Digestible Nutrients Fed per Day per 1000 Lbs., Live Weight, on Sixteen Dairy Farms in Connecticut.

Reference No.	Classes of Food.	Total Nutrients and Energy.					Digested Nutrients and Energy.				
		Protein.	Fat.	Nit.-free Ext.	Fiber.	Fuel Value (Energy).	Protein.	Fat.	Carbo-hydrates.	Nutritive Ratio.	Fuel Value (Energy).
		Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
1	Concentrated food,	1.87	.64	4.00	.65	14800	1.58	.55	3.51	—	11790
	Coarse food, -	1.80	.70	9.61	6.17	35700	.93	.44	9.73	—	21660
	Total food, -	**3.67**	**1.34**	**13.61**	**6.82**	**50500**	**2.51**	**.99**	**13.24**	**6.2**	**33450**
2	Concentrated food,	2.51	.56	6.22	.70	19900	2.05	.49	5.58	—	16300
	Coarse food, -	1.49	.57	9.17	6.00	33400	.74	.36	9.61	—	20700
	Total food, -	**4.00**	**1.13**	**15.39**	**6.70**	**53300**	**2.79**	**.85**	**15.19**	**6.1**	**37000**
3	Concentrated food,	2.71	.96	5.11	.63	19700	2.39	.87	4.65	—	16770
	Coarse food, -	1.20	.54	10.10	5.64	33800	.62	.28	10.13	—	21180
	Total food, -	**3.91**	**1.50**	**15.21**	**6.27**	**53500**	**3.01**	**1.15**	**14.78**	**5.7**	**37950**
4	Concentrated food,	1.81	.55	6.27	.54	18300	1.47	.46	4.99	—	14000
	Coarse food, -	2.14	.86	11.94	7.06	43000	1.15	.47	11.67	—	25800
	Total food, -	**3.95**	**1.41**	**18.21**	**7.60**	**61300**	**2.62**	**.93**	**16.66**	**7.0**	**39800**
5	Concentrated food,	2.64	.88	3.39	.31	15500	2.20	.76	2.64	—	12200
	Coarse food, -	1.90	.73	12.43	7.31	43300	.96	.49	12.55	—	27200
	Total food, -	**4.54**	**1.61**	**15.82**	**7.62**	**58800**	**3.16**	**1.25**	**15.19**	**5.7**	**39400**
6	Concentrated food,	1.56	.54	4.19	.20	13400	1.23	.51	3.58	—	11100
	Coarse food, -	1.49	.67	11.04	6.90	38900	.80	.36	10.97	—	23400
	Total food, -	**3.05**	**1.21**	**15.23**	**7.10**	**52300**	**2.03**	**.87**	**14.55**	**8.1**	**34500**
7	Concentrated food,	1.97	.74	8.96	.51	24400	1.44	.65	7.70	—	19740
	Coarse food, -	1.86	.81	11.23	5.87	38700	1.00	.44	10.30	—	22860
	Total food, -	**3.83**	**1.55**	**20.19**	**6.38**	**63100**	**2.44**	**1.09**	**18.00**	**8.4**	**42600**
8	Concentrated food,	2.08	.64	6.47	1.23	20900	1.60	.50	5.35	—	15050
	Coarse food, -	2.98	.79	11.75	7.74	45100	1.56	.43	11.60	—	26300
	Total food, -	**5.06**	**1.43**	**18.22**	**8.97**	**66000**	**3.16**	**.93**	**16.95**	**6.0**	**41350**
9	Concentrated food,	1.62	.65	3.81	.22	13240	1.20	.58	3.14	—	10500
	Coarse food, -	1.68	.49	8.68	5.62	31760	.96	.25	8.91	—	19450
	Total food, -	**3.30**	**1.14**	**12.49**	**5.84**	**45000**	**2.16**	**.83**	**12.05**	**6.4**	**29950**

TABLE 30.—*(Continued.)*

Reference No.	CLASSES OF FOOD.	TOTAL NUTRIENTS AND ENERGY.					DIGESTED NUTRIENTS AND ENERGY.				
		Protein.	Fat.	Nit.-free Ext.	Fiber.	Fuel Value (Energy).	Protein.	Fat.	Carbo-hydrates.	Nutritive Ratio.	Fuel Value (Energy).
		Lbs.	Lbs.	Lbs.	Lbs.	Cal.	Lbs.	Lbs.	Lbs.		Cal.
10	Concentrated food,	1.57	.55	4.62	.27	14300	1.09	.50	3.72	—	11100
	Coarse food,	2.11	.67	9.16	5.47	34000	1.23	.34	9.32	—	21000
	Total food,	**3.68**	**1.22**	**13.78**	**5.74**	**48300**	**2.32**	**.84**	**13.04**	**6.4**	**32100**
11	Concentrated food,	2.51	.78	5.20	.43	18400	1.91	.70	4.17	—	14250
	Coarse food,	1.58	.57	8.98	6.35	33900	.85	.31	9.29	—	20200
	Total food,	**4.09**	**1.35**	**14.18**	**6.78**	**52300**	**2.76**	**1.01**	**13.46**	**5.7**	**34450**
12	Concentrated food,	2.96	.66	6.40	1.03	22100	2.29	.56	4.84	—	15650
	Coarse food,	1.40	.57	6.38	3.95	24200	.70	.38	6.57	—	15100
	Total food,	**4.36**	**1.23**	**12.78**	**4.98**	**46300**	**2.99**	**.94**	**11.41**	**4.5**	**30750**
13	Concentrated food,	2.25	.72	6.13	.56	19600	1.67	.64	5.27	—	15600
	Coarse food,	1.03	.42	5.97	3.38	21100	.53	.28	5.90	—	13150
	Total food,	**3.28**	**1.14**	**12.10**	**3.94**	**40700**	**2.20**	**.92**	**11.17**	**6.0**	**28750**
14	Concentrated food,	2.23	.85	4.95	.38	17690	1.71	.64	3.79	—	12900
	Coarse food,	1.77	.76	9.77	5.47	34810	.95	.41	9.30	—	20850
	Total food,	**4.00**	**1.61**	**14.72**	**5.85**	**52500**	**2.66**	**1.05**	**13.09**	**5.8**	**33750**
15	Concentrated food,	.92	.46	5.82	.28	15000	.70	.37	4.79	—	11800
	Coarse food,	1.21	.36	9.24	5.55	31300	.65	.19	9.20	—	19100
	Total food,	**2.13**	**.82**	**15.06**	**5.83**	**46300**	**1.35**	**.56**	**13.99**	**11.3**	**30900**
16	Concentrated food,	.82	.53	4.33	.28	12340	.61	.46	3.74	—	10100
	Coarse food,	1.54	.63	9.56	5.10	32760	.83	.34	8.92	—	19500
	Total food,	**2.36**	**1.16**	**13.89**	**5.38**	**45100**	**1.44**	**.80**	**12.66**	**9.3**	**29600**
	Averages of the Above Sixteen Ratios.										
	Concentrated food,						1.58	.58	4.47	—	13700
	Coarse food,						.90	.36	9.62	—	21100
	Total food,						**2.48**	**.94**	**14.09**	**6.5**	**34800**

Table 30, on pages 91 and 92, gives a summary of the rations fed on sixteen dairy farms in Connecticut. In the first five columns are given the total nutrients and total potential energy (fuel value) in the materials fed. The three following columns

give the calculated weights of digestible protein, fats and carbohydrates. As explained on page 74, these weights are calculated from the total nutrients by the use of factors (digestion coefficients) obtained from digestion experiments. These factors are only approximate, and the weights of nutrients obtained by their use are also approximate.

In order that a ration may be complete, there must be enough digestible protein supplied in the food to build new tissues (bone, muscle, milk, etc.) and repair the wastes of the body, and sufficient digestible fat and carbohydrates to furnish heat and muscular energy. If the sum of the digestible carbohydrates and two and one-fourth times the digestible fat of a ration is divided by the amount of digestible protein in the ration, the quotient gives what is called the nutritive ratio. If the quantities of digestible fat and carbohydrates are large relative to the protein, this number will be large and the ration is called a "wide ration;" if the quantities of digestible fat and carbohydrates are relatively small, the quotient is a small number and the ration is a "narrow" one. A ration where the nutritive ratio is much more than 1 : 6 may be called a "wide ration;" if much less it may be called a "narrow ration." "Wide rations" are much more common among American feeders than are "narrow" ones. The column next to the last contains the nutritive ration of the rations fed.

The last column contains the total energy (fuel value) of the digestible nutrients in the rations. These figures were obtained by calculation as explained on page 17 of the present Report.

DISCUSSION OF THE RESULTS OF THE TESTS.

The results brought out in such a study as the one here reported, are tentative rather than final. This investigation was not undertaken with the expectation of obtaining startling facts nor would we be warranted in drawing very definite conclusions from the tests. We do believe, however, that there is much of practical importance to be obtained along this line of inquiry, and that the results herewith presented merit the careful attention of dairymen.

It is probably true that the animals of most of the herds examined were, so far as breed, milk and butter product are concerned, above the average of cows kept for dairy purposes in Connecticut. It is doubtless true that the feeding practiced by the owners of these herds is better than that which is generally

practiced throughout the State. These facts, taken together with the shortness of the periods of observation to which the herds were subjected, have been kept in mind in the following discussion of the results of the tests.

The two chief uses of food are to form the materials of the body and make up its wastes, and to yield energy in the form of heat to keep the body warm, and furnish muscular and other power for the work it has to do. In forming the tissues and fluids of the body, the food serves for building and repair. In yielding energy it serves as fuel. The different nutrients of food act in different ways in accomplishing this purpose. The principal tissue formers are the protein compounds. They build up and repair the nitrogenous materials, as the muscle and bone, and supply the albuminoids of blood, milk, and other fluids. The chief fuel ingredients of the food are the carbohydrates and fat. These are either consumed in the body or are stored as fat to be used as occasion demands. As the protein compounds are the flesh formers, and since the chief function of the fats and carbohydrates is to furnish heat and muscular strength which may be measured by their potential energy or fuel value, it is possible to form a very good idea of the nutrients furnished in different rations by comparing the quantities of digestible protein and amounts of potential energy which the digestible nutrients of rations furnish.

It will be seen from table 30 that the smallest weight of digestible protein fed per day per 1,000 pounds live weight, was 1.35 pounds, and the largest amount was 3.16 pounds. The potential energy or fuel value of the digestible nutrients fed per 1,000 pounds live weight, varied from a minimum of 28,750 calories to a maximum of 42,600 calories. There was also a correspondingly large range in the nutritive ratio of the rations fed. The narrowest ration had the ratio of 1 : 4.5, the widest, of 1 : 11.3.

A RATION FOR A MILCH COW.

Every little while we are in receipt of letters something like this: "I should like to know, in plain, simple language, what is the best way for profit, to feed a cow of 1000 pounds live weight." Unfortunately such a question can at present be answered only approximately.

A proper daily ration will supply in appropriate forms, the protein needed to form the nitrogenous materials of the body

and the energy required for heat and muscular work, and a proper feeding standard will call for sufficient digestible protein, fats, and carbohydrates per day to meet these needs. But just what these weights should be is a matter of considerable uncertainty. No hard and fast rules can be laid down. Individuality (differences of individual animals) prevents the strict application of the general principles which have been learned. Differences in breed, handling, classes of food, powers of digestion, and numerous other conditions known and unknown, tend to make the individual equation one of great importance.

Twenty-five or more years ago there were suggested by Prof. Wolff, an eminent German chemist, certain standard rations for different kinds of animals fed for different purposes. His standard ration for a milch cow calls for 24 pounds of organic matter which should contain 2.5 pounds of digestible protein, .4 pounds of digestible fat, and 12.5 pounds of digestible carbohydrates per day per 1,000 pounds live weight. The potential energy of these digestible nutrients would be about 29,600 calories. Later experience in Germany has inclined toward making the ration narrower and somewhat larger. On the other hand, feeding practice in this country has been quite different, and even our best feeders generally feed a wider ration than that called for by the German standard. Foods rich in fats, and in starch and other carbohydrates are so cheaply and easily obtained in this country that our practice has been to feed them more liberally than has been the case in Germany. Some three or four years ago the New York Station made inquiries by correspondence with some of the best dairymen of the State as to the kinds and amounts of food they were feeding milch cows. Somewhat later the Wisconsin Station made the same inquiry of dairymen of that State. Based upon the replies which were received from eight dairymen in New York and fifteen in Wisconsin, and one study made in Connecticut by the State Station, the Wisconsin Experiment Station* recommended a daily ration, which "may be considered a standard American ration for milch cows in full flow of milk, weighing about 1,000 pounds," of 25.6 pounds organic matter, containing 2.2 pounds digestible protein, .8 of a pound digestible fat, 13.3 pounds digestible carbohydrates. The fuel value of this ration is about 32,200 calories, and its nutritive ratio 1 : 6.9. It will be noticed that the Wisconsin Station recommends in

* F. W. Woll, Wisconsin Experiment Station Bulletin No. 33, October, 1892, page 20.

this standard ration, .3 of a pound less digestible protein than Wolff's standard ration calls for and that the total energy is 2,600 calories larger. While in Germany there is a tendency to the increased use of protein, this standard ration advocates less protein and more of the fuel ingredients of the food.

The German figures were suggested after a great many accurate studies of the feeding practices of the best German feeders, and after a large number of feeding experiments had been conducted by trained specialists. This so-called American standard is practically the average of the feeding practice of 24 dairymen in New York and Wisconsin, and furthermore, as ascertained from the more or less accurate estimates of the feeders themselves as to the amounts fed, etc. The materials fed were not analyzed, but their composition was assumed from the averages of other analyses.

The above is said not in any way to discredit the American work already accomplished, for just such preliminary work as this must be done before other and more accurate observations can be made. The facts are stated, however, to aid us in forming an estimate as to the value of the two standards. Our conditions differ materially from those of Germany, and it may be they are such as to make it better economy to use as wide a ration and with as small an amount of protein as that of the standard prepared by the Wisconsin Experiment Station. This, however, is not at present demonstrated.

The rations here reported upon represent the actual feeding practices of the dairymen whose herds were examined, so far as could be learned by weighing the foods actually fed from day to day, and by determining their composition as accurately as may be by means of chemical analysis. The factors used for calculating the quantities of digestible nutrients are the chief sources of uncertainty entering into this study, but this uncertainty is at present inevitable. The average of these sixteen rations might be suggested as a Connecticut or a New England standard ration for milch cows. But when we consider that there were such wide variations in feeding practice, and when we find such ranges in amounts of protein and in total energy as are pointed out in table 30, on pages 91 and 92, and in table 31, page 97, it would be very unwise to assume that the average of the rations which these sixteen men were feeding was the best possible ration, or anything like the best possible ration, for milch cows in America. Because

carbohydrates and fats are so abundant and so cheap in this country that we feed them liberally, does not imply, much less prove, that we are using them wisely.*

We have so few American data upon the effects of rations, that the teachings of the sixteen studies here reported upon this question are of some value.

In table 31 (page 99) are summarized the rations fed, together with the yield of butter-fat observed during the five days of the tests. The weight of butter-fat was selected rather than the weight of milk, as it is less liable to fluctuation from day to day, and also remains more constant during the earlier months of lactation. In this tabulation the butter yields of all the animals under two years of age, and which were more than eight months in milk flow, have been omitted. Also, in one or two instances, animals giving unusually small yields were also omitted from the tabulations. The animals were of different breeds, and in many ways the conditions were such that the results are not strictly comparable one with the other, and yet in the lack of better data the results are here tabulated to show what light they throw upon the question of the effects of protein and the nutritive ratio upon the production of butter-fat. In this summary table, the figures are made to conform more nearly to "round numbers." Thus the weights of digestible protein are given to the nearest .05 of a pound, 2.51 pounds being taken as 2.50, etc.

The average butter-fat yields for the five days are grouped in accordance with the size of the nutritive ratio of the rations and the weights of protein fed. The butter-yields from the

*After this article was in type and the preceding pages were printed, a Bulletin (Bulletin 38, Wisconsin Experiment Station, by F. W. Woll,) upon "One Hundred American Rations for Dairy Cows," was received. This Bulletin presents results of further observations upon dairy feeding similar to those described in Bulletin 33 of that Station. The rations fed were obtained in the same way as those of the earlier Bulletin. Letters were "sent to four hundred dairy farmers and breeders of dairy stock in all parts of the United States and Canada, asking information concerning their methods of feeding milch cows." * * * "One hundred of the farmers to whom the circulars were sent furnished complete rations containing definite quantities of the feeding stuffs fed daily to their cows, *as exactly as the circumstances would permit.*" [The italics are ours.]

"Combining all of the rations which have been fed by successful dairy farmers and breeders in various parts of our continent, we have the following American ration": Dry matter, 24.51 pounds, containing 2.15 pounds digestible protein, .74 pounds digestible fat and 13.27 pounds digestible carbohydrates. The nutritive ratio of this ration is 1 to 6.9, and the estimated fuel value of its digestible nutrients is 31,250 calories.

This ration differs from the one given in Bulletin 33 of the Wisconsin Station by containing 1.5 pounds less organic matter, .15 pounds less digestible protein, and its potential energy is 950 calories less. The amounts of digestible protein in these rations ranged from 1.05 pounds to 4.34 pounds, the fuel value of the digestible nutrients ranged from 19,050 calories to 45,600, and the nutritive ratios varied from 1 to 4.1, to 1 to 12.8.

herds which had a nutritive ratio greater than 1:6, are given in the fifth, and those which had a nutritive ratio less than 1:6 in the sixth columns. It will be observed that the average five days' yield per cow of the animals of the wider rations was 3.9, and that of the animals of the narrower was 4.5 pounds butter-fat in five days. The animals having the narrower ration produced on the average .6 of a pound more of butter-fat in five days than did those having the wider.

In the last two columns of the table, the butter-fat yields are averaged in accordance with the amount of digestible protein in the rations. It will be observed that the herds which received more than 2.3 pounds of digestible protein per day gave an average of 4.5 pounds per cow of butter-fat in five days, while those under 2.3 gave only 3.6 pounds per cow of butter-fat in the same time. In other words, the animals having the larger amounts of protein gave on the average .9 of a pound more of butter-fat in five days than did those having the smaller quantities of protein.

With the exception of the animals of herd 10, those which are classified as receiving more than 2.3 pounds of digestible protein were all actually receiving about 2.5 or more pounds of digestible protein per day. The animals of this herd (10) were all practically new milch, six of them having just calved, five of the others being less than two months after calving, and all but one being four months or less since calving. This would seem to account, in part at least, for the high yield of butter-fat.

The largest butter-fat yields, with the exception of that from herd 10, were from herds 12, 3, 14 and 1. The rations fed these herds contained respectively 2.99, 3.01, 2.66 and 2.51 pounds of digestible protein. Their nutritive ratios were as follows: 1:4.5, 1:5.7, 1:5.8, 1:6.2. Their fuel values were 30,750, 37,950, 33,750 and 33,450 calories. Too much importance should not be attached to these results, as they may have been partly accidental and due to causes other than feed. It is, nevertheless, a noteworthy fact that in the cases in which the cows were in about the same period of lactation, the yields of butter-fat decreased as the protein decreased, and as the nutritive ratio increased. The largest yield was from a herd receiving a very narrow ration (1:4.5) and one which contained a large amount (about 3 pounds) of digestible protein. The average of all these rations is a good deal wider than that of the German (Wolff's) standard, being very nearly as wide as that of the Wisconsin Station. The weight of

protein in the average of all the rations is in accord with Wolff's ration (2.5 pounds digestible protein), and the rations which seem to have given the best returns contained more protein than Wolff's standard calls for. From the fact that the best butter-fat yields were obtained from a ration containing less than 31,000 calories of potential energy, it seems fair to assume that those which contained upward of 40,000 were quite excessive.

TABLE 31.

Summary of rations fed and yields of butter-fat obtained from sixteen herds examined. The yields of butter-fat are classified in accordance with the nutritive ratios of the ration and the amounts of digestible protein which they contain.

Summary of Rations Fed.					Average Yields of Butter-fat per Cow in 5 Days.			
					Nutritive Ratio.		Digestible Protein.	
Reference No.	Total Organic Matter.	Digestible Protein.*	Nutritive Ratio.†	Fuel value of Digestible Nutrients.	Greater than 1:6	Less than 1:6	More than 2.3 Pounds.	Less than 2.2 Pounds.
	Lbs.	Lbs.	1:	Cal.	Lbs.	Lbs.	Lbs.	Lbs.
1, - -	25.4	2.50	6.0	33450	—	4.6	4.6	—
2, - -	27.2	2.80	6.0	37000	—	4.2	4.2	—
3, - -	26.9	3.00	5.5	37950	—	5.3	5.3	—
4, - -	31.2	2.60	7.0	39800	3.5	—	3.5	—
5, - -	29.6	3.15	5.5	39400	—	4.1	4.1	—
6, - -	26.6	2.05	8.0	34500	3.7	—	—	3.7
7, - -	32.0	2.45	8.5	42600	4.6	—	4.6	—
8, - -	33.7	3.15	6.0	41350	—	4.3	4.3	—
9, - -	22.8	2.15	6.5	29950	3.8	—	—	3.8
10, - -	24.4	2.30	6.5	32100	5.0‡	—	5.0	—
11, - -	26.4	2.75	5.5	34450	—	4.0	4.0	—
12, - -	23.4	3.00	4.5	30750	—	5.5	5.5	—
13, - -	20.5	2.20	6.0	28750	—	3.6	—	3.6
14, - -	26.2	2.65	6.0	33750	—	4.7	4.7	—
15, - -	23.8	1.35	11.5	30900	3.3	—	—	3.3
16, - -	22.8	1.45	9.5	29600	3.8	—	—	3.8
Average,	**26.4**	**2.50**	**6.5**	**34800**	**3.9**	**4.5**	**4.5**	**3.6**

*As here tabulated, the weights of protein are given to the nearest .05 of a pound; thus 2.51 lbs. are called 2.50, etc.

† As here tabulated, the nutritive ratios are taken to the nearest .5; thus 6.2 is called 6; 6.4 is called 6.5, etc.

‡ Cows nearly all new milch. Nutritive ratio 1 : 6.4.

The evidence at present at our command would seem to indicate that the quantity of digestible protein called for by the German (Wolff's) standard is none too large, and that it would be safe in the general run of cases to feed as much or even more protein

if we would obtain the largest yields of butter-fat from our milch cows. It would also, perhaps, be wiser until we have more light than we have at present upon this matter, to make our rations larger, so far as their total energy is concerned, than that of the German standard. The size of the ration suggested by the Wisconsin Station as a standard ration may, when it is measured by its fuel value, not be too large for the demands of our conditions. Feeding stuffs rich in carbonaceous foods (fats and carbohydrates) are abundant and cheap with us, and it is difficult to utilize the foods ordinarily produced on the farm without making our rations larger in total energy than the German standard calls for.

The use of fuel values gives a means of simplifying the calculation of rations. It will be understood that the proportions of fats and carbohydrates are only relative, in other words, that one may be diminished if the other be correspondingly increased. If our theories are correct, the important matter is to provide sufficient protein and sufficient total energy without varying too much from the most desirable relative proportions of the fats and carbohydrates. In other words, a daily ration for a milch cow (1,000 pounds live weight) which would furnish 2.5 pounds of digestible protein and enough digestible carbohydrates and fats to make up the 29,600 calories of energy, would satisfy the requirements of the German (Wolff's) standard, although the relative proportions of the carbohydrates and fats were not the same as called for by this particular standard.

TABLE 32.

German (Wolff's) and Wisconsin Station Standard Rations, together with Averages of 16 Rations here reported upon, and a tentatively suggested Ration.

RATION.	ORGANIC MATTER	DIGESTIBLE NUTRIENTS.				Nutritive Ratio.
		Protein.	Fat.	Carbohydrates.	Fuel Value.	
	Lbs.	Lbs.	Lbs.	Lbs.	Cal.	1:
Wolff's (German) Standard, - -	24.0	2.50	.40	12.50	29600	5.4
Wisconsin Station Standard, 1893, -	25.6	2.30	.80	13.30	32200	6.9
Wisconsin Station Standard, 1894, -	24.5	2.15	.74	13.27	31250	6.9
Average of 16 here reported, - -	26.4	2.48	.94	14.09	34800	6.5
Tentatively suggested ration, - -	25.0	2.50	(.5 to .8*)	(13 to 12*)	31000*	5.6

* See explanation on the opposite page.

The German (Wolff's) standard ration, the standard ration proposed by the Wisconsin Experiment Station, the averages of the 16 rations here reported upon and a suggested tentative ration are given in table 32, on the opposite page.

As has been already pointed out, the chief function of the fats and carbohydrates is to serve as fuel. It appears to be more important that these nutrients should be provided in sufficient quantities for the needs of the body than that they should be supplied in definite relative proportions. In the tentative ration thus suggested, the energy called for could be furnished by about .5 of a pound of digestible fat and 13.0 pounds digestible carbohydrates; by .6 of a pound of digestible fat and 12.5 pounds of digestible carbohydrates; or by .8 of a pound of digestible fat and 12 pounds of digestible carbohydrates.

It must be borne in mind that a "standard ration" itself is only an estimate, an effort to express proportions which approximate the average needs of different animals or the quantities which may be fed. "A great deal of experimenting with the calorimeter and the respiration apparatus, and a great deal of practical testing of animals in experimental stables and on the farm, will be needed in order to enable us to make such estimates entirely satisfactory. When that research shall be accomplished, its results will have a very great value to the farmer."

DAILY VARIATIONS IN AMOUNTS FED.

While there may be more or less uncertainty as to what is a proper ration, there can be no question but what better results will be obtained from careful than from careless feeding. If the animals are overfed one day and underfed, or even properly fed, the next, the milk flow will be affected to the disadvantage of the dairymen. It is not always easy to carefully regulate the quantities of the coarse foods, hay and fodders, which are given from day to day. It is difficult to judge accurately of the weight since the compactness or looseness will deceive the eye. There is, however, very little if any, reason why the same, or nearly the same, weights of the concentrated feeds should not be given from day to day. It may not be practicable to weigh the feeds in the barn when they are being fed, but it is easy to measure the quantities of grain and avoid any great changes in amounts from day to day.

Table 33, which follows, shows the variations in size of the rations which were fed in these sixteen different herds.

TABLE 33.

Variations in Amounts of Food and Total Nutrients per 1000 Lbs., Live Weight, with the same Herd on Different Days, as Shown by the Weights of Food and Nutrients in the Day's Ration, with the Smallest (Minimum) and the Largest (Maximum) Total Energy.

Ref. No.		Concentrated Food.	Coarse Food.	Total Food.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Total Fuel Value.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.
1	Minimum,	4.9	42.7	47.6	2.82	1.02	11.42	6.26	42400
	Maximum,	10.3	44.4	54.7	4.18	1.54	14.77	7.29	55300
	Average,	8.3	43.6	51.9	3.67	1.34	13.61	6.82	50500
2	Minimum,	10.6	57.4	68.0	3.36	.94	13.37	5.48	45300
	Maximum,	11.8	66.2	78.0	4.84	1.28	16.65	7.83	57100
	Average,	11.4	64.7	76.1	4.00	1.13	15.39	6.70	53300
3	Minimum,	10.7	25.8	36.5	3.85	1.45	14.34	5.62	50400
	Maximum,	10.7	30.2	40.9	3.98	1.54	16.26	6.99	57100
	Average,	10.7	27.9	38.6	3.91	1.50	15.21	6.27	53500
4	Minimum,	9.9	29.3	39.2	3.80	1.33	17.14	7.28	58100
	Maximum,	11.2	34.0	45.2	4.16	1.48	19.89	8.39	66600
	Average,	10.6	30.5	41.1	3.95	1.41	18.21	7.60	61300
5	Minimum,	8.0	45.2	53.2	4.43	1.56	14.81	7.08	55500
	Maximum,	8.1	53.7	61.8	4.75	1.69	17.54	8.51	64400
	Average,	8.2	46.3	54.5	4.54	1.61	15.82	7.62	58800
6	Minimum,	7.4	25.6	33.0	3.00	1.19	14.78	6.92	51000
	Maximum,	7.5	29.2	36.7	3.00	1.20	16.27	7.69	55200
	Average,	7.5	26.6	34.1	3.05	1.20	15.23	7.10	52300
7	Minimum,	13.8	23.9	37.7	3.75	1.51	19.80	6.23	61800
	Maximum,	13.8	25.0	38.8	3.89	1.57	20.47	6.51	64000
	Average,	14.1	24.4	38.5	3.83	1.55	20.19	6.38	63100
8	Minimum,	11.8	23.5	35.3	4.46	1.27	15.90	7.55	57300
	Maximum,	12.7	34.6	47.3	5.75	1.61	20.90	10.62	76100
	Average,	12.2	28.7	40.9	5.06	1.43	18.22	8.97	66000
9	Minimum,	6.6	20.1	26.7	3.02	1.04	11.28	5.28	40800
	Maximum,	7.7	23.4	31.1	3.45	1.18	13.17	6.20	47400
	Average,	7.4	22.2	29.6	3.30	1.14	12.49	5.84	45000
10	Minimum,	8.1	20.6	28.7	3.52	1.16	13.04	5.28	45400
	Maximum,	8.0	26.4	34.4	4.04	1.33	15.37	6.69	54200
	Average,	8.2	22.3	30.5	3.68	1.22	13.78	5.74	48300
11	Minimum,	10.4	19.9	30.3	3.92	1.29	13.28	6.05	48700
	Maximum,	10.2	23.8	34.0	4.28	1.39	14.54	7.24	54300
	Average,	10.2	22.6	32.8	4.09	1.35	14.18	6.78	52300
12	Minimum,	12.7	48.2	60.9	4.28	1.19	12.49	4.89	45300
	Maximum,	13.3	50.3	63.6	4.54	1.30	13.76	5.47	49700
	Average,	13.1	48.5	61.6	4.36	1.23	12.78	4.98	46300
13	Minimum,	11.0	37.0	48.0	3.24	1.13	11.88	3.84	40000
	Maximum,	11.1	40.1	51.2	3.31	1.15	12.30	4.04	41400
	Average,	11.2	38.2	49.4	3.28	1.14	12.10	3.94	40700
14	Minimum,	9.4	20.2	29.6	3.83	1.53	13.78	5.35	49200
	Maximum,	9.7	22.9	32.6	4.12	1.66	15.11	5.99	53900
	Average,	9.4	22.3	31.7	4.00	1.61	14.72	5.85	52500
15	Minimum,	8.0	17.3	25.3	1.85	.72	13.19	5.00	40300
	Maximum,	9.5	23.2	32.7	2.55	.94	17.16	6.52	52800
	Average,	8.8	20.3	29.1	2.13	.82	15.06	5.83	46300
16	Minimum,	7.0	18.3	25.3	2.12	1.06	12.37	4.58	39900
	Maximum,	7.2	23.3	30.5	2.49	1.23	14.81	5.78	48100
	Average,	6.9	21.7	28.6	2.36	1.16	13.89	5.38	45100

As pointed out on page 100, the size of a ration can be conveniently measured by its digestible protein and by the fuel value (potential energy) of its digestible nutrients. Since digestion factors are not so very different one from another, it follows that the weights of *total* protein and the *total* fuel values of different rations will serve the purpose of approximate comparisons. In table 33 the total nutrients, not the digestible nutrients, are given.

In general, there seems to have been, as was to be expected with the class of farmers that we visited, considerable care exercised to insure regularity in times of feeding and amounts fed. With the exception of herds 1, 2, 3 and 9, there were no larger variations in the amounts of grain fed from day to day than one would expect. In some cases, notably 3, 5, 6, 7, 10, 11, 13 and 16, the amounts of grain given from day to day were practically constant. In the case of these same herds there was for the most part a corresponding evenness in the daily milk flow and its content of butter-fat. This probably did not follow from the greater uniformity in feed any more than that of the care in general, as it would doubtless be true that the man who is most careful in his feed would be careful in other particulars regarding his herd. In general the quantities of feed given were more uniform where a mixture was made of the grains and then all fed from one measurement than was the case where each grain was fed from a separate bin. The chief objection to feeding the grain in a mixture is that it does not allow as good opportunity for varying the feeds of different animals, as is the case when the grains are fed separately. If a careful person is attending to the feeding, and is trying to feed each animal properly, and is carefully watching the effects of the feed, the best results would doubtless be obtained by feeding the different grain feeds from separate bins. If hired help has to be depended upon, a grain mixture would, in most cases, prove to be the most satisfactory method of feeding grain.

DISCUSSION OF RATIONS.

In the following pages there are given in tabular form the kinds and amounts of the different feeding stuffs actually fed in the 16 herds studied by the Station in the winter of 1893, together with the pounds of protein,* the fuel value of the digestible nutrients, the nutritive ratio and the cost of the ration.

* The terms protein, nutritive ratio, fuel value, etc., are explained on pages 93–100.

There are also given in the case of each ration two suggested changes. It is hoped that out of the forty-eight rations which are given herewith farmers will be enabled to find a ration which is suited to their own needs and circumstances, and that they may be more or less of a guide toward a better feeding. The suggested rations are given as examples of the way in which the same feeding stuffs may be combined in other, and in general, probably better rations. All that has been said in the preceding pages, calling attention to the fact *that there is no such thing at present known as a "best ration," and that all attempts to express in terms of protein and energy the needs of a dairy cow, are only approximations, must be kept in mind in the study of the following rations.*

The costs of the different rations have been calculated by use of the following prices for the different feeds. The prices of the different concentrated feeds are the average, as ascertained by Dr. Jenkins of the State Station, at which they were sold in Connecticut in December, 1893.

Wheat bran,	$19 00	Oats,	$21 00
Wheat middlings,	21 00	Malt sprouts,	18 00
Cotton seed meal,	26 00	Rye meal,	21 00
Buffalo gluten feed,	21 00	Oat feed,	21 00
Chicago gluten meal,	25 00	Hay,	18 00
Cream gluten meal,	25 00	Ensilage,	2 50
O. P. linseed meal,	30 00	Oat hay,	14 00
N. P. linseed meal,	28 00	Poor hay,	10 00
Corn meal,	21 00	Stover,	8 00
Hominy meal,	20 00	Rowen,	14 00
Corn and cob meal,	20 00		

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 1, and Suggested Rations.

Ration No. 1.	As Fed.	Suggested Changes.	
	A.	B.	C.
Wheat bran,	2.8 pounds.	4.0 pounds.	5.0 pounds.
Wheat middlings,	1.6 pounds.	2.0 pounds.	—
Linseed meal,	1.8 pounds.	2.0 pounds.	2.0 pounds.
Buffalo gluten feed,	2.1 pounds.	3.0 pounds.	5.0 pounds.
Hay,	11.0 pounds.	4.0 pounds.	—
Oat hay,	5.3 pounds.	8.0 pounds.	3.0 pounds.
Ensilage,	27.3 pounds.	25.0 pounds.	50.0 pounds.
Digestible protein,	2.50 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	33,450 calories.	31,550 calories.	31,350 calories.
Nutritive ratio, 1:	6.2	5.8	5.7
Cost of ration,	26.3 cents.	23.3 cents.	23.3 cents.

Ration No. 1, as fed, was fairly well balanced. The fuel value was perhaps somewhat larger than necessary. Nearly all the cows of this herd were young, all except five being three years or under. It is likely that animals at this stage of growth, especially when in milk flow, would need more protein than mature animals would. The chief criticism to be made in this case is the same as can be made of the majority of rations fed upon New England farms. It contains too much of first quality hay. Taking the hay at its market value, such a ration is more expensive than one which uses more of the cheaper coarse feeds and less of good hay. Each of the suggested rations (B and C) contains less hay than the one actually fed. The coarse feed of ration C is almost wholly ensilage. Each of the suggested rations contains the same amounts of digestible protein as the ration which was actually fed. The fuel value is about 2,000 calories less in the suggested rations than in the one actually fed, and the nutritive ratio is smaller in consequence. Ration B costs three cents less, and ration C five cents less than A.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Hera No. 2, and Suggested Rations.

Ration No. 2.	As Fed.	Suggested Changes.	
	A.	B.	C.
Wheat middlings,	4.7 pounds.	5.0 pounds.	6.0 pounds.
Chicago gluten meal,	3.7 pounds.	5.0 pounds.	4.0 pounds.
Provender, Ground oats,	1.0 pounds.	—	1.0 pounds.
Provender, Corn meal,	2.0 pounds.	1.0 pounds.	2.0 pounds.
Good hay,	7.2 pounds.	—	7.0 pounds.
Poor hay,	2.2 pounds.	3.0 pounds.	—
Ensilage,	55.3 pounds.	50.0 pounds.	25.0 pounds.
Digestible protein,	2.80 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	37,000 calories.	31,450 calories.	30,650 calories.
Nutritive ratio, 1:	6.1	5.8	5.5
Cost of ration,	2.72 cents.	20.3 cents.	22.3 cents.

Ration No. 2, as fed, was large in protein and fuel value, but was fairly balanced. If about one-ninth less of each of the ingredients had been used, it would have come very closely in its protein and fuel value to the tentatively suggested standard ration of page 100. A grain mixture of one part oats and two parts corn, such as used here (frequently called provender), seems to be quite a common grain feed in Connecticut. There are some reasons to doubt the economy of using oats as a feed

for milch cows. The suggested ration B does not contain oats. Chicago gluten meal contains a great deal of protein, and it would not be wise to change at once animals which had not been receiving gluten meal, to a ration containing as much gluten meal as ration B. All changes of feeds should be made gradually, so that the animal may become accustomed to the new ration without derangement. Ration C is heavier in grain than either B or A. It will be observed that both the rations B and C contain the weights of protein called for by the suggested standard, and that the fuel value of B is a little greater and that of C a little less than the standard calls for. Ration C is five cents and ration B seven cents cheaper than ration A. If ration A were reduced one-ninth, it would give a fairly well-balanced ration of about the proper size and its cost would be reduced to 24 cents. B and C would then be respectively two and four cents cheaper than A.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 3; and Suggested Rations.

Ration No. 3.	As Fed.	Suggested Changes.	
	A.	B.	C.
Cotton seed meal,	4.1 pounds.	3.0 pounds.	2.0 pounds.
Buffalo gluten feed,	3.1 pounds.	3.0 pounds.	6.0 pounds.
Hominy meal,	3.5 pounds.	4.0 pounds.	1.0 pounds.
Hay,	11.0 pounds.	5.0 pounds.	10.0 pounds.
Stover,	9.3 pounds.	15.0 pounds.	10.0 pounds.
Potatoes,	7.6 pounds.	—	—
Digestible protein,	3.00 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	37,950 calories.	31,400 calories.	31,600 calories.
Nutritive ratio, 1:	5.7	5.6	5.6
Cost of ration,	25.7 cents.*	21.5 cents.	22.9 cents.

* Exclusive of the potatoes.

Ration No. 3, as fed, contained about three pounds of digestible protein, and nearly 38,000 calories of energy. The ration was about one-sixth larger than called for by the tentatively suggested standard. The ration contained a very large amount (4.1 pounds) of cotton seed meal. Buffalo gluten feed is not as rich in protein as is either Chicago gluten meal or cream gluten. Still the cotton seed meal and the Buffalo gluten, taken together furnish two-thirds of the protein which would be called for by the standard. Hominy meal differs but little from corn meal in its composition. It contains about the same percentage of protein as corn meal, and more of fat and less of

carbohydrates, so that the fuel values of the two are about the same (1,400 calories per pound). The ration, as fed, contained nearly eight pounds per day of potatoes. Potatoes are not very valuable as a feed for the actual nutrients which they contain. They are popularly supposed to have some physiological action aiding digestion, etc., which is not shown by their chemical composition. It may be that as large weights of cotton seed and gluten as were here used can be safely fed, but so heavy a ration as this would demand careful attention of the feeder to avoid milk fever and other diseases incidental to high feeding. The suggested rations (B and C) are much smaller than A, though their nutritive ratios are about the same. If one-sixth less of each of the ingredients of ration A were fed, the ration would be much like B and C in total protein and fuel value. The use of less hay and more stover in rations B and C make them cost less than ration B, even after reducing the size of A one-sixth.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 4, and Suggested Rations.

RATION NO. 4.	AS FED.	SUGGESTED CHANGES.	
	A.	B.	C.
Wheat bran,	3.7 pounds.	6.0 pounds.	5.0 pounds.
Cotton seed meal,	1.5 pounds.	3.0 pounds.	3.0 pounds.
Corn and cob meal,	5.4 pounds.	—	5.0 pounds.
Hay,	21.4 pounds.	3.0 pounds.	5.0 pounds.
Stover,	9.1 pounds.	20.0 pounds.	15.0 pounds.
Digestible protein,	2.60 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	39,800 calories.	31,300 calories.	31,300 calories.
Nutritive ratio, 1:	7.0	5.6	5.6
Cost of ration,	33.8 cents.	20.3 cents.	23.7 cents.

Ration No. 4, as fed, contains a little more protein than called for by the tentatively suggested ration, and its fuel value (nearly 40,000 calories) is far in excess. The nutritive ratio is wider than it is probably profitable to feed. This ration contained over 21 pounds of hay, which made it expensive, costing about 34 cents per 1,000 pounds live weight per day. Each of the suggested rations B and C contains much less hay than A, and the grain is used in such quantities as to make the total ration contain about 2½ pounds of protein and 31,000 calories of potential energy. The cost of these suggested rations is much less than that of A. It would not be wise to make a sudden change from such a ration as A to either B or C or other narrow ration.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 5, and Suggested Rations.

Ration No. 5.	As Fed.	Suggested Changes.	
	A.	B.	C.
Wheat middlings,	2.2 pounds.	6.0 pounds.	4.0 pounds.
Chicago gluten meal,	2.7 pounds.	3.0 pounds.	2.0 pounds.
Cotton seed meal,	3.3 pounds.	1.0 pounds.	2.0 pounds.
Hay,	13.3 pounds.	6.0 pounds.	15.0 pounds.
Ensilage,	33.0 pounds.	50.0 pounds.	30.0 pounds.
Digestible protein,	3.15 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	39,400 calories.	30,500 calories.	31,300 calories.
Nutritive ratio, 1:	5.7	5.5	5.6
Cost of ration,	28.1 cents.	23.0 cents.	26.6 cents.

All of the grain feeds of ration No. 5 are quite rich in protein. The ration itself is a very large one, though very well balanced. The ration as actually fed furnished 3.15 pounds of digestible protein, and its fuel value was over 39,000 calories. If one-fifth less of each of the ingredients of the ration had been fed, it would have been of about the same size as the suggested rations B and C, and its cost would have been about the same as B, and considerably less than C. Ration C is an illustration of the fact that hay, if used in considerable amount, makes an expensive ration. Ration B contains two pounds more of grain than ration C, but costs nearly four cents less. This difference is chiefly due to the smaller amounts of hay and larger amounts of ensilage used in B than in C.

Daily Ration per 1,000 Pounds Live Weight Actually Fed to Herd No. 6, and Suggested Rations.

Ration No. 6.	As Fed.	Suggested Changes.	
	A.	B.	C.
Corn meal,	3.7 pounds.	2.0 pounds.	—
Wheat middlings,	2.0 pounds.	5.0 pounds.	5.0 pounds.
Cotton seed meal,	1.8 pounds.	3.0 pounds.	3.0 pounds.
Oat hay,	4.7 pounds.	5.0 pounds.	10.0 pounds.
Hay,	14.4 pounds.	—	—
Stover,	7.5 pounds.	14.0 pounds.	12.0 pounds.
Digestible protein,	2.05 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	34,500 calories.	31,000 calories.	31,250 calories.
Nutritive ratio, 1:	8.1	5.6	5.6
Cost of ration,	27.5 cents.	20.4 cents.	21.0 cents.

Ration No. 6 is low in protein and high in potential energy. The nutritive ratio (8.1) is greater than that of any of the rations which have preceded it. It will be observed that half the grain was corn meal, a feed relatively rich in the carbonaceous ingredients (fats and carbohydrates) and deficient in protein. Oat hay contains rather more protein than ordinary hay does. Hence the daily use of five pounds of oat hay made this ration better than it otherwise would have been. In each of the suggested rations (B and C) good hay was omitted. The digestible protein, the fuel values and nutritive ratio and cost of rations B and C are practically the same. A change from such a ration as A to B or C, or other narrow rations, should be made gradually. These suggested rations would probably be better if part of the cotton seed meal were replaced by gluten or linseed meal.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 7, and Suggested Rations.

Ration No. 7.	As Fed.	Suggested Changes.	
	A.	B.	C.
Provender, Ground oats,	2.8 pounds.	—	2.0 pounds.
Provender, Corn meal,	5.7 pounds.	3.0 pounds.	4.0 pounds.
Wheat middlings,	5.6 pounds.	4.0 pounds.	6.0 pounds.
O. P. linseed meal,	—	4.0 pounds.	3.0 pounds.
Hay,	24.4 pounds.	19.0 pounds.	11.0 pounds.
Digestible protein,	2.45 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	42,600 calories.	30,000 calories.	31,000 calories.
Nutritive ratio, 1:	8.4	5.6	5.6
Cost of ration,	36.7 cents.	30.5 cents.	26.4 cents.

Ration No. 7, as fed, consisted of hay, middlings and provender (oats and corn ground together). This ration contained about enough digestible protein, but the total fuel value was very large. The feeding of 24 pounds of hay made the ration an expensive one. In ration B, in order to get sufficient protein, linseed meal has been suggested in pretty large amount. It is safer to feed four pounds of linseed than the same amount of cotton seed, as the cotton seed would contain one-third more protein. While the total protein of B is not greatly different from that of A, the nutritive ratio is so very different that any changes should be made gradually. In both rations B and C, good hay is the only coarse food. If stover or oat hay were substituted for part of the hay of B and C, the rations would be much more economical ones.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 8, and Suggested Rations.

Ration No. 8.	As Fed.	Suggested Changes.	
	A.	B.	C.
Wheat bran,	4.9 pounds.	5.0 pounds.	5.0 pounds.
Corn and cob meal,	7.3 pounds.	4.0 pounds.	7.0 pounds.
Malt sprouts,	—	6.0 pounds.	4.0 pounds.
Hay,	28.7 pounds.	15.0 pounds.	12.0 pounds.
Digestible protein,	3.15 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	41,350 calories.	31,500 calories.	30,850 calories.
Nutritive ratio, 1:	6.0	5.7	5.6
Cost of ration,	38.0 cents.	27.6 cents.	26.2 cents.

Ration No. 8, as fed, was very large, containing 3.15 pounds of digestible protein, and its fuel value was over 41,000 calories. The ration was fairly well balanced, but was altogether too large. If about one-fifth less had been fed, the food would probably have been utilized to better advantage. The use of so much hay made the ration an expensive one. In the suggested rations malt sprouts have been added to the grain feed used. In B, six pounds of malt sprouts replace three pounds of corn and cob meal and 14 pounds of A; and in ration C, four pounds of malt sprouts are fed with 17 pounds less hay than in ration A. Reducing the quantities of hay and increasing the grain feeds reduced the cost of the ration very materially. If, however, some of this hay could be replaced by some cheaper form of coarse foods, the price of the ration would be still farther reduced.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 9, and Suggested Rations.

Ration No. 9.	As Fed.	Suggested Changes.	
	A.	B.	C.
Corn meal,	2.0 pounds.	4.0 pounds.	2.0 pounds.
Wheat bran,	1.5 pounds.	2.0 pounds.	1.0 pounds.
Cotton seed meal,	1.5 pounds.	1.0 pounds.	1.0 pounds.
Cream gluten,	1.5 pounds.	1.0 pounds.	1.0 pounds.
Hay,	12.0 pounds.	—	—
Rowen,	5.1 pounds.	12.0 pounds.	15.0 pounds.
Stover,	5.1 pounds.	10.0 pounds.	10.0 pounds.
Digestible protein,	2.15 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	29,950 calories.	31,500 calories.	30,600 calories.
Nutritive ratio, 1:	6.4	5.7	5.6
Cost of ration,	23.8 cents.	24.0 cents.	20.1 cents.

Ration No. 9 is quite small, as estimated by its fuel value, and it is also deficient in protein. Its nutritive ratio is quite large (6.4). The use of more rowen and stover in ration B, with more corn meal and about the same quantities of bran and other nitrogenous feeds as in A, gives a larger and better balanced ration for the same cost. The use of larger quantities of rowen in C, with a corresponding decrease in the quantity of grains fed, gives a well balanced ration of about the proper size for 20 cents. The value of rowen and of clover in particular as a feed is pointed out in both these rations and in ration No. 10, where by using 15 or 16 pounds of rowen with stover and a comparatively small quantity of grain, a complete ration is furnished for 20 cents per 1000 pounds live weight.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 10, and Suggested Rations.

Ration No. 10.	As Fed.	Suggested Changes.	
	A.	B.	C.
Corn meal,	4.6 pounds.	2.0 pounds.	2.0 pounds.
Cotton seed meal,	2.3 pounds.	1.5 pounds.	2.5 pounds.
Wheat bran,	1.3 pounds.	2.0 pounds.	3.0 pounds.
Stover,	6.9 pounds.	8.0 pounds.	8.0 pounds.
Rowen,	10.2 pounds.	16.0 pounds.	7.0 pounds.
Hay,	5.2 pounds.	—	8.0 pounds.
Digestible protein,	2.30 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	32,100 calories.	30,800 calories.	30,900 calories.
Nutritive ratio, 1:	6.4	5.6	5.6
Cost of ration,	23.3 cents.	20.3 cents.	23.5 cents.

Ration No. 10, as fed, differs from 9 only in being a little larger. Practically the same suggested changes are made for this ration as for No. 9, only as gluten meal was not used in No. 10, the quantities of cotton seed and wheat bran are correspondingly increased. Ration B of No. 10 and ration C of No. 9 are among the least expensive of the suggested rations.

Ration No. 11 (see next page), as fed, was a well balanced ration, but was larger than probably needed. The two suggested rations, B and C, are alike so far as their digestible protein, fuel value and nutritive ratio are concerned. The grain mixtures and coarse foods of the two are, however, quite different. Ration B, which uses oat hay instead of merchantable hay, is four cents cheaper than C.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 11, and Suggested Rations.

Ration No. 11.	As Fed.	Suggested Changes.	
	A.	B.	C.
Wheat middlings,	3.1 pounds.	2.0 pounds.	2.0 pounds.
Corn meal,	3.1 pounds.	—	6.0 pounds.
Cotton seed meal,	3.1 pounds.	3.0 pounds.	3.0 pounds.
Wheat bran,	0.8 pounds.	3.0 pounds.	2.0 pounds.
Hay,	12.1 pounds.	—	10.0 pounds.
Oat hay,	6.7 pounds.	12.0 pounds.	—
Stover,	3.8 pounds.	10.0 pounds.	5.0 pounds.
Digestible protein,	2.75 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	34,450 calories.	31,500 calories.	31,500 calories.
Nutritive ratio, 1:	5.7	5.7	5.7
Cost of ration,	28.2 cents.	21.2 cents.	25.2 cents.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 12, and Suggested Rations.

Ration No. 12.	As Fed.	Suggested Changes.	
	A.	B.	C.
Wheat bran,	3.8 pounds.	2.0 pounds.	3.0 pounds.
Corn meal,	2.3 pounds.	4.0 pounds.	3.0 pounds.
Cotton seed meal,	2.4 pounds.	1.0 pounds.	—
Malt sprouts,	4.6 pounds.	6.0 pounds.	8.0 pounds.
Ensilage,	41.1 pounds.	50.0 pounds.	25.0 pounds.
Hay,	7.4 pounds.	3.0 pounds.	8.0 pounds.
Digestible protein,	3.00 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	30,750 calories.	31,100 calories.	31,000 calories.
Nutritive ratio, 1:	4.5	5.6	5.6
Cost of ration,	24.7 cents.	21.8 cents.	23.5 cents.

Ration No. 12 is the narrowest of the 16. It contains three pounds of digestible protein, and the fuel value of the ration is not quite 31,000 calories. Its nutritive ratio is 1 to 4.5. The animals upon this ration gave the best returns, so far as the five days' tests show, of any of the herds examined, and so far as it is allowable to make deductions from one such test, the use of larger quantities of protein than suggested in the tentative standard ration of page 100, would seem to be justified. The suggested rations B and C are wider and contain less protein than A. Their fuel values are about the same as that of A, and their costs are a little less. If malt sprouts could be bought at the price ($12.50 per ton) at which they were used in this ration in 1893, the ration would be a very cheap one.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 13, and Suggested Rations.

Ration No. 13.	As Fed.	Suggested Changes.	
	A.	B.	C.
Cotton seed meal,	1.6 pounds.	2.5 pounds.	3.0 pounds.
Wheat middlings,	6.4 pounds.	6.0 pounds.	4.0 pounds.
Corn meal,	3.2 pounds.	4.0 pounds.	5.0 pounds.
Ensilage,	30.7 pounds.	40.0 pounds.	25.0 pounds.
Hay,	7.5 pounds.	5.0 pounds.	10.0 pounds.
Digestible protein,	2.20 pounds.	2.45 pounds.	2.50 pounds.
Fuel value,	28,750 calories.	31,300 calories.	31,300 calories.
Nutritive ratio, 1:	6.0	5.8	5.6
Cost of ration,	22.8 cents.	23.3 cents.	25.5 cents.

Ration No. 13 was a small one in both its digestible protein and its fuel value. Ration B differs from A principally in containing a pound more of cotton seed meal and some less hay. It contains a little less digestible protein and its nutritive ratio is a little wider than that suggested on page 100. Ration C contains less wheat middlings and ensilage and more corn meal and hay than either A or B. It is a well balanced ration of about the proper size. Each of the rations B and C is a little more expensive than A.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 14, and Suggested Rations.

Ration No. 14.	As Fed.	Suggested Changes.	
	A.	B.	C.
Cream gluten,	3.1 pounds.	3.5 pounds.	4.0 pounds.
Oat feed,	3.1 pounds.	2.0 pounds.	4.0 pounds.
Wheat bran,	3.1 pounds.	5.0 pounds.	4.0 pounds.
Hay,	18.7 pounds.	—	7.0 pounds.
Stover,	3.6 pounds.	20.0 pounds.	12.0 pounds.
Digestible protein,	2.65 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	33,750 calories.	31,600 calories.	31,500 calories.
Nutritive ratio, 1:	5.8	5.7	5.7
Cost of ration,	26.0 cents.	19.2 cents.	24.1 cents.

Ration No. 14, as fed, is a little larger than the standard calls for, but is fairly well balanced. The use of quite large quantities of hay makes the ration somewhat expensive. Ration B is a well balanced ration of the standard size, costing only 19 cents. This low cost is due to the use of stover alone for coarse food. If some other material than oat feed were used, the ration

could be made a little cheaper. C differs from B chiefly in having more hay and less stover. It is a considerably more expensive ration than B.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 15, and Suggested Rations.

Ration No. 15.	As Fed.	Suggested Changes.	
	A.	B.	C.
Corn and cob meal,	5.8 pounds.	2.0 pounds.	5.0 pounds.
Rye meal,	1.0 pounds.	—	2.0 pounds.
Wheat bran,	0.9 pounds.	3.0 pounds.	3.0 pounds.
Oat feed,	0.6 pounds.	3.0 pounds.	—
O. P. linseed meal,	0.6 pounds.	3.0 pounds.	2.0 pounds.
Gluten meal bran,	—	1.0 pounds.	—
Malt sprouts,	—	—	4.0 pounds.
Hay,	11.8 pounds.	6.0 pounds.	2.0 pounds.
Stover,	8.5 pounds.	12.0 pounds.	11.0 pounds.
Digestible protein,	1.35 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	30,900 calories.	30,800 calories.	31,400 calories.
Nutritive ratio, 1:	11.3	5.6	5.7
Cost of ration,	23.0 cents.	23.2 cents.	22.8 cents.

Ration No. 15 is the widest, that is, contains the least digestible protein in proportion to its other nutrients, of any of the rations examined. It has only 1.35 pounds of digestible protein, with a nutritive ratio of 1 to 11.3. It is not practicable to make a well balanced ration out of the materials which were fed in this case; hence the grains fed in B and C differ in kind from those of A. It is to be observed that both B and C are well balanced rations furnishing 2½ pounds of digestible protein, and have practically the same fuel values and costs as A. This instance illustrates the fact that it costs no more to feed a well balanced than an illy balanced ration. There can be little doubt but that either B or C would give a great deal better returns than were obtained from A.

Ration No. 16 (see next page) is also very wide. It contains only 1.45 pounds of digestible protein and less than 30,000 calories of energy. The addition of more grain, including linseed meal, makes a ration which is well balanced and at no more cost, as is shown by rations B and C. It will be observed that while B and C contain about the same quantities of digestible protein and differ little in their fuel values, that the rations are quite different in their make-up.

Daily Ration per 1000 Pounds Live Weight Actually Fed to Herd No. 16, and Suggested Rations.

RATION NO. 16.	AS FED.	SUGGESTED CHANGES.	
	A.	B.	C.
Corn meal,	3.1 pounds.	2.0 pounds.	1.0 pounds.
Wheat bran,	1.7 pounds.	6.0 pounds.	3.0 pounds.
Buffalo gluten feed,	2.1 pounds.	4.0 pounds.	5.0 pounds.
O. P. linseed meal,	—	2.0 pounds.	2.5 pounds.
Hay,	14.2 pounds.	—	6.0 pounds.
Poor hay,	3.8 pounds.	6.0 pounds.	3.0 pounds.
Stover,	3.8 pounds.	7.0 pounds.	8.0 pounds.
Digestible protein,	1.45 pounds.	2.50 pounds.	2.50 pounds.
Fuel value,	29,600 calories.	31,000 calories.	31,000 calories.
Nutritive ratio, 1:	9.3	5.6	5.6
Cost of ration,	23.9 cents.	22.0 cents.	23.6 cents.

As stated at the commencement of this paper, the studies here reported upon were undertaken as the beginning of an investigation into the feeding practices and the characters of the dairy herds of Connecticut. The investigation is being continued during the present winter, and it is expected that full accounts of the later results will be printed in the Annual Report of this Station for 1894.

It is our belief that the results thus far obtained merit the careful consideration of dairy farmers. The subject of cattle feeding and handling is a large one, and only general principles can be advanced. No hard and fast rules for feeding are now known, and doubtless none ever will be known. It is nevertheless true that the man who exercises the largest amount of good judgment, based upon all that the most advanced science can bring to him, and who tries to put into practice the knowledge thus acquired, will be on the much surer road to success than one who works blindly. There may be no "best" breed, no "best" ration, and no "best" way of handling dairy stock, yet there are bad sides to all three questions, and the man who learns to avoid the bad is well on the road toward the best.

METEOROLOGICAL OBSERVATIONS.

BY C. S. PHELPS.

The meteorological observations made at the Storrs Station during 1893 have been similar to those of past years. The Station equipment consists of the ordinary instruments for obtaining temperature, pressure of the air, humidity, rainfall and snowfall, uniform with those used by voluntary observers for the U. S. Weather Service. In addition to the records made at Storrs, the rainfall for the growing season has been recorded by farmers conducting field experiments for the Station, and a few other voluntary observers.

The rainfall for the year, as measured at the Station (46.7 in.), is a little below the average of the State. The average for six Connecticut stations of the New England Meteorological Society, having records covering a period of ten or more years prior to 1890, is 49.1 inches. The records at Storrs for the five years ending with 1893, give an average of 46.8 inches.

The precipitation was largest during May and smallest during the months of June, July, and the first half of August. It will be noticed that the rainfall was deficient during just that portion of the year when most needed by the greater part of our common farm crops. These conditions caused great injury to such crops as corn, potatoes, grass and tobacco.

The temperature for the first two months of the year was considerably below the average, and the snowfall was quite heavy during the latter part of the winter.

The spring opened a little later than usual. The last damaging frost occurred May 8th. The summer months were characterized by frequent drying winds and a moderate temperature, with light rainfall till after the middle of August.

Light frost appeared on low ground Sept. 3d. The first killing frost occurred Oct. 17th. This gave a growing season of 161 days since the last damaging frost in the spring, while the average growing season, since the Station began its observations in 1888, is 145 days.

During October the rainfall was large, and the supply of water in wells and springs was generally replenished.

Through the kindness of the New England Meteorological Society we are able to publish rainfall records from fourteen of their Stations.

Table 34 gives the rainfall as recorded for the six months ending October 31st, for twenty-two localities in the State, and table 35 gives the summary of observations made by the Station at Storrs.

TABLE 34.

Rainfall during Six Months ending Oct. 31, 1893.

Locality.	Observer.	Inches per Month. May.	June.	July.	August.	September.	October.	Total.
Falls Village, - -	M. H. Dean, - -	5.52	2.49	3.33	5.50	3.89	3.99	24.72
Oxford, - - -	H. R. Stevens, -	7.63	2.64	2.80	7.81	2.51	5.31	28.70
Norwalk, - -	G. C. Comstock,* -	6.84	2.10	3.64	6.57	2.38	5.16	26.69
Waterbury, - -	N. J. Welton,* -	6.44	1.82	3.31	7.22	1.75	5.21	25.75
New Hartford, -	R. R. Smith,* -	7.16	2.09	2.51	5.47	3.23	6.48	26.94
Canton, - - -	G. J. Case,* - -	7.52	5.00	1.95	4.91	3.23	5.92	28.53
West Simsbury, -	S. T. Stockwell,* -	6.75	3.52	2.37	4.29	2.83	5.01	24.77
Hartford, - -	Prof. S. Hart,* -	7.44	2.06	1.64	4.14	2.36	4.72	22.36
Wallingford, - -	Mrs. B. F. Harrison,*	8.06	2.35	2.24	4.75	—	4.87	—
New Haven, - -	Weather Bureau,* -	7.08	2.07	1.89	4.86	2.24	4.75	22.89
Middletown, - -	C. W. Hubbard,* -	7.20	2.99	—	4.98	2.55	5.54	—
South Manchester, -	K. B. Loomis, -	5.03	3.01	3.42	4.58	2.61	4.62	23.27
Vernon, - - -	E. H. Lathrop, -	5.59	2.98	2.63	4.15	2.06	—	—
Storrs, - - -	Experiment Station,	7.12	1.98	1.58	3.79	2.38	6.71	23.56
North Franklin, -	C. H. Lathrop, -	8.34	3.73	2.25	3.43	2.75	4.91	25.41
Lebanon, - -	J. H. Tucker, -	8.19	2.17	1.17	3.64	3.56	5.56	24.29
Lebanon, - -	Edward Hoxie, -	8.63	3.81	1.11	3.53	3.42	4.42	24.92
Colchester, - -	S. P. Willard,* -	7.97	1.90	1.43	4.23	3.06	6.60	25.19
New London, - -	Weather Bureau,* -	5.02	3.60	1.51	3.69	2.29	2.20	18.31
Lake Konomoc, -	N. London W. Wks.*	7.17	2.63	0.91	3.37	2.72	—	—
Voluntown, - -	Rev. E. Dewhurst,*	7.10	2.57	1.48	4.14	2.22	3.83	21.34
N. Grosvenordale, -	C. H. Truesdell,* -	6.03	1.75	1.27	4.03	2.44	4.55	20.07
Average, - -		**6.99**	**2.65**	**2.12**	**4.69**	**2.69**	**5.02**	**24.32**

* New England Meteorological Society Observers.

TABLE 35.

Meteorological Summary for 1893.

OBSERVATIONS MADE AT STORRS BY THE STATION.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Means.	Totals.
Highest barometer, - - -	30.50	30.79	30.52	30.61	30.29	30.32	30.19	30.24	30.37	30.59	30.68	30.90	30.50	—
Lowest barometer, - - -	29.17	29.04	29.34	29.44	29.23	29.68	29.61	29.49	29.66	29.38	29.63	29.42	29.42	—
Mean barometer, - - -	29.97	30.10	30.05	30.07	29.88	30.02	29.94	29.97	30.02	30.10	30.10	30.10	30.03	—
Highest temperature, - -	50.5	48.5	48.8	68.4	84.8	91.1	88.8	89.5	77.2	74.8	62.0	55.7	70.0	—
Lowest temperature, - - -	-6.0	-3.0	6.0	20.0	35.5	45.0	47.8	46.0	37.0	25.0	14.0	-2.0	22.1	—
Mean temperature, - - -	17.3	23.5	30.3	42.0	54.5	64.2	67.9	68.0	55.9	51.7	38.1	27.8	45.1	—
Relative humidity, - - -	—	—	—	76.3	74.9	79.2	71.7	77.0	79.5	78.9	—	—	76.8	—
Total precipitation, - - -	2.39	5.88	4.67	3.82	7.12	1.98	1.58	3.79	2.58	6.71	2.45	3.68	—	46.65
Number of days with precipitation of .01 inches or more,	9	13	13	11	13	9	8	11	9	6	6	13	—	121
Number of clear days, - -	9	8	13	9	10	10	17	15	14	11	8	6	—	130
Number of fair days, - - -	12	9	8	9	11	12	10	9	6	13	13	16	—	128
Number of cloudy days, - -	10	11	10	12	10	8	4	7	10	7	9	9	—	107

FIELD EXPERIMENTS WITH FERTILIZERS.

BY C. S. PHELPS.

The Station has continued its coöperative field experiments through a sixth year, the plan being essentially the same as that adopted in the spring of 1888.

The field experiments conducted by the Station at Storrs and on farms in different parts of the State for the year 1893, have been largely "Soil Tests." One "Special Nitrogen" experiment on Hungarian grass was made at the Station.

Owing to the severe drought during July and August the crops on nearly all of the fields experimented upon were considerably injured, and the effects of the fertilizers were much less than might otherwise have resulted. On many of the fields the texture and the amount of organic matter of the soil of different plots varied considerably, and hence the available moisture supply was not the same on all. This, in most of the experiments, influenced the plot yields unequally and makes deductions from the use of the fertilizers more or less unreliable. For this reason there are given, for several of the experiments, simply tabulations of the results without deductions or comment. In other words, most of the experiments are made of little value by the drought, nevertheless it seems wise to put the results on record.

The object aimed at is to study the soils of different regions, learn their deficiencies, and find how to apply fertilizers so as to meet the needs of particular soils and crops in an economical way. The wide variations in soils indicate that the results of any one experiment are applicable only to the particular soil experimented upon, or to soils of a similar character. Where this class of experimenting is wholly on the Station farm, the work has only a local value, and in order to make the experiments of highest value to the farmers of the State they must be carried out in a considerable number of places. If the important operations, such as the selection of the field, the laying out of the plots, the planting, the application of the fertilizers, and the weighing and harvesting of the crop, are under the supervision of an officer of the

Station, there is no reason why the work cannot be carried out with the same degree of accuracy on farms about the State as at the Station.

A summary of the results of fifteen years' experimenting by soil tests with fertilizers on farms throughout New England will be found in the last annual report of this Station.* The reader is referred to this for a more extended report on the value of such experiments and the practical deductions.

The following persons have coöperated in the experiments during the past year:

	POST OFFICE.
M. H. Dean, - - - - - - -	Falls Village.
Elbert Manchester, - - - - - -	Bristol.
M. H. & H. G. Sperry, - - - - -	Bolton.
William E. Alvord, - - - - - -	Bolton.
C. H. Lathrop, - - - - -	North Franklin.
C. A. Sharpe, - - - - - - -	Abington.

In connection with most of the experiments, rainfall records have been kept during the growing season. On page 117 will be found the rainfall records for the six months ending October 31st, for 22 localities in the State.

TABLE 36.

Percentages of Dry Matter of Corn in Ears (Grain and Cob), and the Number of Pounds of Ears required for a Bushel of Shelled Corn.

NAME AND LOCALITY.	Water-free Corn in sample (ears) at Harvest.		Pounds of ears at harvest to equal 56 lbs. shelled corn with 11 % water.	
	Good.	Poor.	Good.	Poor.
	%	%	Lbs.	Lbs.
M. H. Dean, Lime Rock, - - -	57.5	52.5	83	97
William E. Alvord, Bolton, - -	57.3	55.5	87	98
M. H. & H. G. Sperry, Bolton, - -	55.7	51.0	89	97
Elbert Manchester, Bristol, - -	54.2	40.0	92	125
C. A. Sharpe, Abington, - - -	60.9	53.0	82	94
C. H. Lathrop, North Franklin, -	56.2	50.7	88	98

*See Fifth Annual Report, 1892, pages 67–84.

POUNDS REQUIRED FOR A BUSHEL OF DRY SHELLED CORN.

The percentages of water at harvest in the corn of the different experiments are found to vary considerably. The field weights are not an accurate measure of the value of the crop. The moisture and the proportions of cob to corn vary widely on different fields, but have been found to be fairly uniform on different plots of the same field. Moisture tests of the corn, at the time of harvest, have been made for all but one of the experiments in order to find the number of pounds of ears required to make a bushel of dry shelled corn. The differences in the percentages of water-free corn may be ascribed to two causes; variations in the proportion of corn to cob and variations in the moisture contained in the ears at harvest. Owing to heavy rainfalls this year, while the corn was in the shocks, it was not as well dried as usual at harvest. Mr. Manchester grew a dent variety, and the corn seemed quite moist at harvest. The corn in nearly all cases contained a larger percentage of water than usual, and there are quite wide variations in the different experiments.

These differences point out the importance of knowing the moisture in the crop of each field instead of depending upon averages. From 70 to 75 pounds are commonly considered a sufficient weight of ears to make one bushel of dry shelled corn, but in these experiments an average of 88 pounds was required.

SOIL TEST EXPERIMENTS.

The plan of experiments for soil tests consists in applying, on parallel plots of land, fertilizers containing nitrogen, phosphoric acid, and potash, singly, two by two, and all three together. The fertilizing materials were in all cases supplied by the Station in standard commercial forms, such as nitrate of soda, dissolved bone-black, and muriate of potash. In all of the experiments here described, the cost of the fertilizer is estimated from the retail selling prices of the materials, plus $2 per ton for mixing and freights.

On the following pages, the comparative yields of the experiments discussed are shown by means of diagrams. The fertilizers and the weights are given at the left of the diagram. The lengths of the lines represent the comparative yields per acre from the different plots, and the figures given in the last column show the actual yields per acre.

At the close of this article will be found a series of tabular statements, giving the results in detail. In all cases, the yield of shelled corn per acre is reported on the basis of 11 per cent. water, and the stover on the basis of field weights.

EXPERIMENTS BY M. H. DEAN.

The field upon which these experiments were located is in the Housatonic Valley. The soil is alluvial, light loam, with very little vegetable matter, and apparently worn down by previous cropping without manure.

Experiments similar to the one of 1893 were conducted by the Station on this field in 1889 and 1890, the order of plots and the kinds of fertilizers being the same each year. The quantities of fertilizers used in 1890 were double those used in 1889, for each plot. The most marked results of the earlier experiments were the large increase in yield from the use of potash and nitrogen, and the apparently injurious effects of phosphoric acid. In both the years 1889 and 1890 plot E, with nitrate of soda and muriate of potash, gave a larger yield than plot G with the same fertilizers and dissolved bone-black in addition. In 1890, plot G*a* was added in place of the plaster plot (H). This plot was similar to G in the amount of nitrogen and potash used, but had a very large amount of phosphoric acid. The yield on G*a* was somewhat greater than on G, but was less than on E, where only potash and nitrogen were used.

This led to the query as to whether the soluble phosphoric acid, in the form of dissolved bone-black, did not prove injurious to the crop. The following was offered, at that time, as a possible means of explaining the peculiar phenomenon:

"This apparently injurious effect of soluble phosphates is most frequent on sandy soils, naturally deficient in nitrogen. The most plausible explanation seems to be that the soluble phosphoric acid, in the absence of an abundant supply of available nitrogen, checks the growth and hastens maturity. The leaves turn yellow and the crop prematurely ripens, and a smaller yield results."

In 1891 an experiment in green manuring was undertaken on this field for the purpose of ascertaining if the absence of an available supply of nitrogen might account for the lighter yields of corn when soluble phosphates were present in excess.

Cow peas were sown broadcast upon the entire field about June 1st, 1891, at the rate of one bushel per acre. A medium heavy growth was produced, and the crop was plowed under and

the field seeded to rye the first week in September. The weight of unthreshed rye per acre at harvest is given in the following table:

WEIGHTS OF UNTHRESHED RYE PER ACRE.

	Lbs. per Acre.		Lbs. per Acre.		Lbs. per Acre.
Plot 0, - -	3130	Plot D, -	4180	Plot F, -	4470
Plot A, -	3740	Plot 00, -	4060	Plot G, -	4610
Plot B, -	3840	Plot E, -	4600	Plot G*a*, -	4470
Plot C, -	4400				

From this tabulation it will be noticed that the plots to which potash had been applied in the corn experiments (see diagram on next page) gave the largest yields of rye, although the phosphoric acid plot (B) gave better results than nitrogen plot (A).

From the diagram on the next page giving the yields of corn for the three years 1889, 1890, and 1893, it will be seen that naturally the soil was especially lacking in potash and nitrogen; and that the clover plowed under added largely to the supply of available nitrogen. In 1893, mineral fertilizers alone (plot F) gave nearly as large yields as plot G, which had in addition to the minerals, 160 pounds of nitrate of soda.

Early in the spring of 1892, red clover seed, at the rate of ten pounds per acre, was sown broadcast upon the entire field, and a fair "catch" resulted. The clover developed quite rapidly after the rye was harvested, and a heavy growth was produced during the fall of 1892. The clover was plowed under May 20 and 22, 1893, and the land prepared for a soil test experiment with corn. The kinds and amounts of fertilizers used were the same as for our regular soil tests (see weights for 1889), except plot G*a* took the place of plaster. This plot had the same amount of nitrogen and potash as G, but double the amount of phosphoric acid.

A striking peculiarity of the soils of this region is the presence of large quantities of phosphates. The soil is alluvial, and was apparently formed from the decomposition of limestone formations located along the Housatonic Valley to the northward. This limestone evidently contains phosphates, and by its decomposition these phosphates must have been added to the soil. In the earlier experiments the dissolved bone-black (phosphoric acid) seemed to be detrimental to the crop, but in the latter test (1893), in the presence of an abundance of available nitrogen, it proved of value, although the increase in yield was slight where double the ordinary quantity was used (Plot G*a*).

SOIL TEST WITH FERTILIZERS ON CORN.

By M. H. DEAN, Lime Rock.

Fertilizers and Yields for 1889, 1890 and 1893.

Plot No.	Fertilizers. Kind.	Lbs. per Acre (1889 and 1893.)	Lbs. per Acre. (1890.)	Yield Shelled Corn per Acre in 1889, 1890, 1893. (11 % Water.) Comparative Scale.	Bu.
O.	Nothing, -	—	—	1889	9.9
				1890	3.9
				1893	10.3
A.	Nit. of Soda, -	160	320	1889	16.9
				1890	12.9
				1893	16.2
B.	Dis. Bone-black,	320	640	1889	9.1
				1890	5.0
				1893	8.9
C.	Mur. of Potash,	160	320	1889	18.8
				1890	7.2
				1893	28.5
D.	Nit. of Soda, - Dis. Bone-black,	160 320	320 640	1889	18.0
				1890	17.0
				1893	22.0
OO.	Nothing, -	—	—	1889	14.7
				1890	7.3
				1893	19.3
E.	Nit. of Soda, - Mur. of Potash,	160 160	320 320	1889	25.3
				1890	44.4
				1893	32.6
F.	Dis. Bone-black, Mur. of Potash,	320 160	640 320	1889	17.4
				1890	8.8
				1893	36.9
G.	Nit. of Soda, - Dis. Bone-black, Mur. of Potash,	160 320 160	320 640 320	1889	22.1
				1890	35.0
				1893	39.5
* H.	Plaster, - -	400	—	1889	14.8
* Ga.	Nit. of Soda, - Dis. Bone-black, Mur. of Potash,	— — —	320 1280 320	1890	40.4
				1893	42.8

* H of 1889 is the same plot as G*a* of 1890 and 1893.

SOIL TEST WITH FERTILIZERS ON CORN, 1893.

By M. H. DEAN, Lime Rock.

Plot No.	Fertilizers.		Yield Shelled Corn per Acre. (11 % Water.)	
	Kind.	Lbs. per Acre.	Comparative Scale.	Bu.
o.	Nothing, - -	—		10.3
A.	Nitrate of Soda, -	160		16.2
B.	Dis. Bone-black, -	320		8.9
C.	Muriate of Potash,	160		28.5
D.	Nitrate of Soda, - Dis. Bone-black, -	160 320		22.0
oo.	Nothing, - -	—		19.3
E.	Nitrate of Soda, - Muriate of Potash,	160 160		32.6
F.	Dis. Bone-black, - Muriate of Potash,	320 160		36.9
G.	Nitrate of Soda, - Dis. Bone-black, - Muriate of Potash,	160 320 160		39.5
Ga.	Nitrate of Soda, - Dis. Bone-black, - Muriate of Potash,	160 640 160		42.8

Four points are especially emphasized in the experiment of 1893:

(1) The necessity of preparing fertilizers so as to meet the needs of soils.

(2) The importance of stocking light, porous soils with a large amount of organic nitrogen in order to supply nitrogen to the crop and get the best results from the mineral fertilizers.

(3) The value and economy of legumes for improving light, porous soils, by plowing in as manure.

(4) The evidence that soluble phosphates may prove a detriment to the crop on certain light soils, unless there is an abundance of available nitrogen present in the soil. In the absence of available nitrogen the phosphates seem to hasten maturity and thus shorten the life of the plant. This is a probable explanation of the way the phosphoric acid diminishes the yield.

SOIL TEST EXPERIMENT BY THE STATION ON COW PEAS.

This experiment is the fourth in a series of tests planned as a rotation soil test experiment, the same fertilizers being used on the same plots year after year.* Beginning with 1890 the crops grown on this field have been corn, potatoes, oats and cow peas. The plan was to grow scarlet clover in 1893, but the crop failed to make a good growth while young, and hence the test with clover was abandoned.

The field slopes gently to the south, but not enough to cause serious washing. The soil is a heavy loam, and the subsoil is a yellow, compact, clay loam. In 1889 it was noticed that the soil seemed to be poorer toward the west side of the field. For this reason the field was laid out into two half-acre experiments, the order of the plots on the two being reversed, as per diagram.

ARRANGEMENT OF PLOTS IN STATION EXPERIMENT.

UNMANURED STRIPS SEPARATE THE PLOTS.

For fertilizers used on plots, see diagram on opposite page.

EAST.

NORTH.		SOUTH.
	Plot o.	Plot Y.
	Plot A.	Plot X.
	Plot B.	Plot ooo.
	Plot C.	Plot G.
	Plot oo.	Plot F.
	Plot D.	Plot E.
	Plot E.	Plot D.
	Plot F.	Plot oo.
	Plot G.	Plot C.
	Plot ooo.	Plot B.
	Plot X.	Plot A.
	Plot Y.	Plot o.

WEST.

The yields of the duplicate plots in each case are averaged in estimating the yield per acre. This helps toward eliminating the errors due to irregularities of soil. All of the plots were laid out running north and south.

* For description and results of earlier experiments on this field, see Report of this Station, 1890, pp. 69–71.

Beside the regular soil test, two other plots were added, one (Y) with a medium amount of stable manure and the other (X) with a smaller quantity of manure, but in addition dissolved bone-black at the rate of 160 pounds per acre.

SOIL TEST WITH FERTILIZERS ON COW PEAS.

BY THE STATION, STORRS.

Plot No.	Fertilizers. Kind.	Fertilizers. Lbs. per Acre.	Yield Per Acre. (Vines 83 % Water.) Comparative Scale.	Yield Per Acre. Lbs.
0.	Nothing, - -	—		10,230
A.	Nitrate of Soda, -	160		10,960
B.	Dis. Bone-black,	320		10,710
C.	Muriate of Potash,	160		11,680
00.	Nothing, - -	—		9,725
D.	Nitrate of Soda, - Dis. Bone-black,	160 320		12,920
E.	Nitrate of Soda, - Muriate of Potash,	160 160		13,335
F.	Dis. Bone-black, Muriate of Potash,	320 160		15,790
G.	Nitrate of Soda, - Dis. Bone-black, Muriate of Potash,	160 320 160		16,210
000	Nothing, - -	—		12,100
X.	Stable Manure, - Dis. Bone-black,	12,000 160		15,795
Y.	Stable Manure, -	16,000		15,875

Twenty pounds per acre of scarlet clover seed were sown April 25th, and the fertilizer was applied May 9th. Very heavy rainfalls, which occurred early in May, packed the surface soil and so retarded the growth of the clover that the weeds soon gained control. Early in June it was decided that the field should be planted to cow peas. The land was thoroughly harrowed June 5th and 6th, and all weeds destroyed. The field was thinly stocked with clover about two inches high at this time. The Clay variety of cow peas was sown June 7th, in drills 2 feet 4 inches apart, at the rate of 40 quarts per acre. The seed germinated well, and by June 17th the field was well stocked. No

marked differences were noticed in the growth on different plots till the latter part of July.

July 31st it was observed that the plots to which dissolved bone-black had been applied were making better growth than the other plots. This was noticeable on plots B, D and F. Later in the season the plots with potash took the lead.

As is usually the case with legumes, potash seemed to have the most marked influence on the yields. Plot C gave the heaviest growth of any of the plots with single fertilizers, while E with nitrogen and potash gave a considerably better growth than D with nitrogen and phosphoric acid.

The increase from the use of nitrogen (nitrate of soda or manure) was not very marked, as may be seen by comparing the yields on F with only mineral fertilizers with that on G with a complete fertilizer, and on Y with manure and X with manure and dissolved bone-black.

The percentage composition and the yield of the different nutrients per acre are shown in table 37, on the opposite page.

The influence of nitrogen on the composition of the crop of this experiment is quite interesting. Unlike the grasses, the legumes seem to be but little affected in their protein or nitrogen content by the addition of nitrogen in the fertilizers. Potash appeared to have the most marked influence over the percentage of protein in the crop. Plot C with potash alone, and Plot F with potash and phosphoric acid, gave the highest percentages of protein in the crop.

Plot G with a complete fertilizer costing $12 per acre, yielded only 420 pounds per acre more than plot F, which had the same mineral fertilizers, but no nitrogen, and cost $8 per acre. The total protein on the two plots was very different from the total crop. Plot G, with nitrate of soda, yielded protein at the rate of 496 pounds, while F, without the nitrate, produced at the rate of 534 pounds per acre.

This experiment points out two reasons for not using nitrogen compounds to any considerable degree, in the fertilizers used in growing leguminous crops. The total yield is but little if any greater where nitrogen is used, and the protein in the crop does not seem to be increased by its use.

TABLE 37.

Proximate Composition of Water-free Substance of Cow Peas and Proximate Ingredients per Acre in Cow Peas.

Plot No.	FERTILIZERS.	Laboratory No.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Nitrogen.
	*Composition.**		%	%	%	%	%	%
O.	Unmanured, - -	1234	17.11	3.76	47.50	19.95	11.68	2.44
OO.	Unmanured, - -	1235	19.21	3.69	44.03	20.06	13.01	2.76
OOO.	Unmanured, - -	1236	18.83	3.07	44.17	21.02	12.91	2.70
	Av. of Unmanured,	—	**18.38**	**3.51**	**45.24**	**20.34**	**12.53**	**2.63**
A.	Nitrate of Soda, -	1237	17.02	3.44	48.59	19.86	11.09	2.45
B.	Dis. Bone-black, -	1238	18.94	3.28	45.23	20.22	12.33	2.70
C.	Muriate of Potash, -	1239	19.76	3.50	42.77	20.31	13.66	2.83
D.	Nitrate of Soda, - Dis. Bone-black, -	1240	17.24	3.62	47.21	19.91	12.02	2.46
E.	Nitrate of Soda, - Muriate of Potash, -	1241	16.01	3.48	45.06	22.60	12.85	2.34
F.	Dis. Bone-black, - Muriate of Potash, -	1242	19.88	3.61	41.06	22.53	12.92	2.92
G.	Nitrate of Soda, - Dis. Bone-black, - Muriate of Potash, -	1243	18.02	3.58	42.65	22.24	13.51	2.65
X.	Stable Manure, - Dis. Bone-black, -	1244	19.17	3.55	43.80	21.40	12.08	2.80
Y.	Stable Manure, -	1245	18.08	3.73	44.49	21.42	12.28	2.63
	FERTILIZERS.	Dry Matter. Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
O.	Unmanured, - -	1739	297	65	827	347	203	—
OO.	Unmanured, - -	1653	317	61	728	332	215	—
OOO.	Unmanured, - -	2057	387	64	909	432	265	—
	Av. of Unmanured,	—	**334**	**63**	**821**	**370**	**228**	—
A.	Nitrate of Soda, -	1863	317	64	905	370	207	—
B.	Dis. Bone-black, -	1821	345	59	824	369	224	—
C.	Muriate of Potash, -	1986	393	69	849	404	271	—
D.	Nitrate of Soda, - Dis. Bone-black, -	2196	378	79	1037	438	264	—
E.	Nitrate of Soda, - Muriate of Potash, -	2267	363	78	1021	513	292	—
F.	Dis. Bone-black, - Muriate of Potash, -	2684	534	96	1101	605	348	—
G.	Nitrate of Soda, - Dis. Bone-black, - Muriate of Potash, -	2755	496	98	1174	614	373	—
X.	Stable Manure, - Dis. Bone-black, -	2685	515	95	1176	575	324	—
Y.	Stable Manure, -	2699	487	100	1202	578	332	—

* For composition on fresh basis, see page 21 of this Report.

SPECIAL NITROGEN EXPERIMENT BY THE STATION ON HUNGARIAN GRASS.

The field used for the special nitrogen experiment on Hungarian grass is the same as was used during the past three years for similar experiments on mixed meadow grasses.*

DETAILS OF THE EXPERIMENT.

The experiment was similar to the special nitrogen experiments with corn, described in previous Annual Reports of the Station.† It will be observed that plots 1 to 5, on which nitrogen, phosphoric acid, and potash are applied singly and two by two, and also plot 6 with mixed minerals, were omitted from these experiments. These soil test plots were omitted for lack of room in the field, and not because interesting results might not have been expected from them.

The general plan of the experiment was to apply the same quantities of mineral fertilizers (potash and phosphoric acid) to all the plots except two, which were left unmanured. Nitrogen was added to all of the fertilized plots, except two, at the rate of 25, 50 and 75 pounds per acre. The whole experiment, as planned, includes the use of nitrogen in the three forms: nitrates, ammonia salts, and organic nitrogen. In the experiment with meadow grasses (1890–91–92), the three plots of the organic nitrogen group were omitted from the results, as there was much clover with the grasses. No fertilizers were applied on this part of the field during 1891 and 1892, and the amount of clover in the crop of 1892 was considerably reduced.

The field has a gentle slope to the south and southwest, but not enough to occasion the washing of fertilizers from one plot to another. The plots contained one-eighth acre each, and were laid out so as to conform to the slope of the field. They are 302.5 feet long by 18 feet wide, with unfertilized strips 3 feet wide between plots.

The soil is a medium heavy loam, and the sub-soil is slightly clayey and adhesive. The soil was in a comparatively low state

* Reports of this Station, 1890, pp. 44–56; 1891, pp. 29–40; 1892, pp. 36–46.

† See Reports of this Station, 1888, pages 72 to 89; 1889, pages 103 to 119; 1890, pages 71 to 74.

of fertility. The land is not quickly affected by drought, and appears to retain fertilizers readily. The natural drainage is good.

A crop of mixed meadow grasses was grown on the field in 1893 before the Hungarian experiment was started. This was cut and harvested June 8th–11th, and the field was plowed a few days later preparatory to the experiment. The crop of hay consisted mostly of fine grasses, except there was in addition some clover on plots *6b*, 13, 14 and 15. The yield was about one ton per acre.

Owing to the severe drought at this period, it was thought advisable not to sow the seed at once. Hence the soil was simply kept free of weeds by harrowing several times, till July 8th, at which time the experiment was started.

NOTES DURING GROWTH.

The field was sown with Hungarian grass July 8th, at the rate of one bushel per acre. The fertilizer was applied after sowing the seed, and the land was then rolled. Light rains July 9th and 12th caused the seed to germinate fairly well. July 31st the field was found to be fairly well stocked, and the Hungarian was two to three inches high. At this date very little difference could be observed in the growth on the different plots.

August 8th the crop was 7 to 10 inches high on all of the fertilized plots, and appeared heavier and darker colored on the plots having had the larger quantities of nitrogen. The growth on the nothing plots was small, thin and pale-colored, and on the mixed mineral plots was slender and pale-colored. The growth on plots 8 and 9 was somewhat uneven.

August 28th the crop was nearly grown and beginning to blossom. The growth on the fertilized plots seemed to be about twice as heavy as on the mixed mineral plots. The growth seemed heavier and darker green where the most nitrogen was used. The heaviest growth appeared to be on the sulphate of ammonia plots. The crop on the nothing plots was small, pale and thin, while that on the mineral plots was pale in color, but somewhat heavier than on the nothing plots. Plot *6b* showed a much heavier growth than *6a*.

The crop on the strips between the plots was cut and removed August 31st–Sept. 2d. The crop on the plots was cut Sept. 4th. At this time it was noticed that the growth on plots 8 and 9 was quite uneven, and that plot *6b* showed a heavier crop than *6a*. The Hungarian was a little past full bloom when cut.

RESULTS OF THE EXPERIMENTS.

In the diagram which follows, the comparative yields per acre are shown. The field weights for each plot are calculated to a uniform water basis of 11 per cent. moisture (89 per cent. dry matter).

Yield of Hay per Acre.

Plot No.	Fertilizers.		Yield Per Acre. (11 % Water.)	
	Kind.	Lbs. per Acre.	Comparative Scale.	Lbs.
0.	Nothing, - -	—		3034
7.	Mixed Min's, as 6*a*, Nitrate of Soda, -	480 160		3754
8.	Mixed Min's, as 6*a*, Nitrate of Soda, -	480 320		3853
9.	Mixed Min's, as 6*a*, Nitrate of Soda, -	480 480		3863
6*a*.	Dis. Bone-black, * Muriate of Potash,*	320 160		2624
10.	Mixed Min's, as 6*a*, Sulp. of Ammonia,	480 120		3638
11.	Mixed Min's, as 6*a*, Sulp. of Ammonia,	480 240		3857
12.	Mixed Min's, as 6*a*, Sulp. of Ammonia,	480 360		4130
6*b*.	Mixed Min's, as 6*a*,	480		3580
00.	Nothing, - -	—		2321
13.	Mixed Min's, as 6*a*, Ammonite, - -	480 192		3133
14.	Mixed Min's, as 6*a*, Ammonite, - -	480 384		3248
15.	Mixed Min's, as 6*a*, Ammonite, - -	480 576		3414

* Mixed Minerals.

The yields obtained in previous years on the plots (0 and 00) having no manure and those having minerals alone (6*a* and 6*b*) would seem to indicate that the soil is tolerably uniform. The yield of the present year on these plots is very irregular. Plot 0 is on a steeper incline than the others, and it was thought that on this account it might have lost more than the others by washing, but this season the yield was much larger than that from plot 6*a*, which was supplied with mineral fertilizers. The yield from the mixed mineral plots also greatly lacked in uniformity. This may be due to the fact that there was considerable clover in the hay crop of one of these plots (6*b*) which was harvested in June, and the clover stubble and roots may have increased the available nitrogen on this plot over that on the other mixed mineral plot, 6*a*.

There was a gradual increase in yield with the increased quantities of nitrogen used. The crop in general did not show a very marked increase from the use of fertilizers. This was doubtless due in part to the severe drought during July and the greater part of August. The experiment confirms those made on the field with meadow grasses, in demonstrating the importance of nitrogenous fertilizers in the growth of grasses.

TABLE 38.

Proximate Composition of Water-free Substance of Hungarian.

Plot No.	FERTILIZERS.	Laboratory No.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Nitrogen.
			%	%	%	%	%	%
0.	Unmanured, - - -	1249	8.09	3.41	53.00	29.32	6.18	1.20
00.	Unmanured, - - -	1250	9.82	3.22	50.65	29.74	6.57	1.47
	Average of Unmanured, -	—	**8.96**	**3.31**	**51.83**	**29.53**	**6.37**	**1.34**
6a.	Dis. Bone-black, Mur. of Potash, } Mixed Min'ls,	1251	8.48	2.96	50.79	30.40	7.37	1.24
	Mixed Minerals, as No. 6a,	1252	9.26	2.98	49.73	30.14	7.89	1.35
6b.	Av. of Mixed Minerals, -	—	**8.87**	**2.97**	**50.26**	**30.27**	**7.63**	**1.30**
	Nitrate of Soda Group.							
7.	Mixed Minerals, as No. 6a, Nit. of Soda (25 lbs. N.),	1253	8.07	2.73	51.40	30.95	6.85	1.19
8.	Mixed Minerals, as No. 6a, Nit. of Soda (50 lbs. N.),	1254	10.16	3.35	49.01	30.31	7.17	1.50
9.	Mixed Minerals, as No. 6a, Nit. of Soda (75 lbs. N.),	1255	14.21	3.71	44.78	29.60	7.70	2.12
	Sulphate of Ammonia Group.							
10.	Mixed Minerals, as No. 6a, Sulph. of Am. (25 lbs. N.),	1256	8.48	3.21	50.20	30.40	7.71	1.27
11.	Mixed Minerals, as No. 6a, Sulph. of Am. (50 lbs. N.),	1257	8.66	2.76	49.12	31.64	7.82	1.30
12.	Mixed Minerals, as No. 6a, Sulph. of Am. (75 lbs. N.),	1258	10.92	3.13	46.29	31.71	7.95	1.64
	Organic Nitrogen Group.							
13.	Mixed Minerals, as No. 6a, Ammonite (25 lbs. N.),	1259	10.65	3.26	46.77	31.61	7.71	1.58
14.	Mixed Minerals, as No. 6a, Ammonite (50 lbs. N.),	1260	11.90	3.40	45.93	31.14	7.63	1.78
15.	Mixed Minerals, as No. 6a, Ammonite (75 lbs. N.),	1261	13.04	3.41	45.88	29.80	7.87	1.96

COMPOSITION OF THE CROP.

Samples of from 15 to 19 pounds were taken from each plot just before the hay was carted. These were cut into one-half inch lengths and sub-samples (of 3 to 5 lbs.) were taken for analysis.

From table 38 it will be seen that the nitrogen supplied in the fertilizers had considerable influence on the percentage of protein. The average percentage of protein in the water-free substance of the crop on the mineral plots was 8.87 per cent., on the plots with 25 lbs. of nitrogen 10.24 per cent., and with 75 lbs. of nitrogen, 12.72 per cent. This illustrates the double value of nitrogen on the grasses. The yield is generally increased with the larger quantities of nitrogen used, and the protein, and hence the feeding value of the crop is considerably increased.

TABLE 39.

Proximate Ingredients per Acre in Hungarian.

Plot No.	FERTILIZERS.	Laboratory No.	Water-free.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
0.	Unmanured, - - -	1249	2731	221	93	1447	801	169
00.	Unmanured, - - -	1250	2089	205	67	1059	621	137
	Av. of Unmanured, - -	—	**2410**	**213**	**80**	**1253**	**711**	**153**
6*a*.	Dis. Bone-black, Mur. of Potash, Mixed Minerals,	1251	2362	200	70	1200	718	174
6*b*.	Mixed Minerals, as No. 6*a*, -	1252	3132	290	93	1558	944	247
	Av. of Mixed Minerals, -	—	**2747**	**245**	**82**	**1379**	**831**	**210**
	Nitrate of Soda Group.							
7.	Mixed Minerals, as No. 6*a*, Nitrate of Soda (25 lbs. N.),	1253	3379	273	92	1737	1046	231
8.	Mixed Minerals, as No. 6*a*, Nitrate of Soda (50 lbs. N.),	1254	3468	352	116	1700	1051	249
9.	Mixed Minerals, as No. 6*a*, Nitrate of Soda (75 lbs. N.),	1255	3477	494	129	1557	1029	268
	Sulphate of Ammonia Group.							
10.	Mixed Minerals, as No. 6*a*, Sulph. of Am. (25 lbs. N.),	1256	3274	277	105	1644	996	252
11.	Mixed Minerals, as No. 6*a*, Sulph. of Am. (50 lbs. N.),	1257	3471	300	96	1706	1098	271
12.	Mixed Minerals, as No. 6*a*, Sulph. of Am. (75 lbs. N.),	1258	3717	406	117	1720	1179	295
	Organic Nitrogen Group.							
13.	Mixed Minerals, as No. 6*a*, Ammonite (25 lbs. N.),	1259	2820	301	92	1319	891	217
14.	Mixed Minerals, as No. 6*a*, Ammonite (50 lbs. N.),	1260	2923	348	99	1343	910	223
15.	Mixed Minerals, as No. 6*a*, Ammonite (75 lbs. N.),	1261	3073	401	105	1409	916	242

TABLE 40.

SPECIAL NITROGEN EXPERIMENT ON HUNGARIAN.

Weight and Cost of Fertilizers per Acre, Total Crop and Increase of Crop over that of the Nothing Plots.

Plot No.	FERTILIZERS.	Weight of Fertilizers.	Cost of Fertilizers.	Total Crop (11 % Water).	Gain or Loss (-) Over Nothing Plots.
		Lbs.	$	Lbs.	Lbs.
0.	Nothing, - - - - - - -	—	—	3034	—
7.	Mixed Minerals, as No. 6*a*, - - - Nitrate of Soda (25 lbs. Nitrogen), -	480 160	12.00	3754	1076
8.	Mixed Minerals, as No. 6*a*, - - - Nitrate of Soda (50 lbs. Nitrogen), -	480 320	15.96	3853	1175
9.	Mixed Minerals, as No. 6*a*, - - - Nitrate of Soda (75 lbs. Nitrogen), -	480 480	19.92	3863	1185
6*a*.	Dissolved Bone-black, Muriate of Potash, } Mixed Minerals,	320 160	8.00	2624	-54
10.	Mixed Minerals, as No. 6*a*, - - - Sulphate of Ammonia (25 lbs. Nitrogen),	480 120	12.44	3638	960
11.	Mixed Minerals, as No. 6*a*, - - - Sulphate of Ammonia (50 lbs. Nitrogen),	480 240	16.88	3857	1179
12.	Mixed Minerals, as No. 6*a*, - - - Sulphate of Ammonia (75 lbs. Nitrogen),	480 360	21.32	4130	1452
00.	Nothing, - - - - - - -	—	—	2321	—
6*b*.	Mixed Minerals, as No. 6*a*, - - -	480	8.00	3580	902
13.	Mixed Minerals, as No. 6*a*, - - - Ammonite (25 lbs. Nitrogen), - -	480 192	12.02	3133	455
14.	Mixed Minerals, as No. 6*a*, - - - Ammonite (50 lbs. Nitrogen), - -	480 384	16.06	3248	570
15.	Mixed Minerals, as No. 6*a*, - - - Ammonite (75 lbs. Nitrogen), - -	480 576	20.10	3414	736

SOIL TEST WITH FERTILIZERS ON CORN.

TABLE 41.—BY M. H. DEAN, LIME ROCK.

Plot No.	Fertilizers per Acre. Kind.	Weight.	Cost.	Yield per Plot. Ears. Good.	Ears. Poor.	Stover.	Yield per Acre. Shelled Corn. 11 % Water. Good.	Poor.	Stover.	Gain or Loss (-) over Noth'g Plots.
		Lbs.	$	Lbs.	Lbs.	Lbs.	Bu.	Bu.	Lbs.	Bu.
O.	Nothing,	—	—	58	32	223	7.0	3.3	2230	—
A.	Nitrate of Soda,	160	3 96	99	41	258	12.0	4.2	2580	1.0
B.	Dis. Bone-black,	320	4 40	40	40	226	4.8	4.1	2260	-6.3
C.	Muriate of Potash,	160	3 48	193	51	431	23.3	5.2	4310	13.
D.	Nitrate of Soda, Dis. Bone-black,	160 320	8 48	116	77	334	14.0	8.0	3340	6.8
OO.	Nothing,	—	—	93	79	255	11.2	8.1	2550	—
E.	Nitrate of Soda, Muriate of Potash,	160 160	7 52	225	53	383	27.1	5.5	3830	17.4
F.	Dis. Bone-black, Muriate of Potash,	320 160	8 00	259	55	525	31.2	5.7	5250	21.7
G.	Nitrate of Soda, Dis. Bone-black, Muriate of Potash,	160 320 160	12 00	283	46	540	34.8	4.7	5400	24.3
Ga.	Nitrate of Soda, Dis. Bone-black, Muriate of Potash,	160 640 160	16 72	328	33	580	39.5	3.3	5800	27.6

SOIL TEST WITH FERTILIZERS ON COW PEAS.

TABLE 42.—BY THE STATION.

Plot No.	Fertilizers.	Per Acre. Weight of Fertilizers.	Per Acre. Cost of Fertilizers.	Field Weights at Cutting. Yield per Plot 1-12 Acre	Field Weights at Cutting. Yield per Acre.	Dry Matter in Crop per Acre.	Green Crop per Acre, 83 % Water.
		Lbs.	$	Lbs.	Lbs.	Lbs.	Lbs.
O.	Nothing,	—	—	755	9,060	1739	10,230
A.	Nitrate of Soda,	160	3.96	878	10,536	1863	10,960
B.	Dis. Bone-black,	320	4.40	824	9,888	1821	10,710
C.	Muriate of Potash,	160	3.48	1035	12,420	1986	11,680
OO.	Nothing,	—	—	785	9,420	1653	9,720
D.	Nitrate of Soda, Dis. Bone-black,	160 320	8.48	1051	12,612	2196	12,920
E.	Nitrate of Soda, Muriate of Potash,	160 160	7.52	1228	14,736	2267	13,340
F.	Dis. Bone-black, Muriate of Potash,	320 160	8.00	1312	15,744	2684	15,790
G.	Nitrate of Soda, Dis. Bone-black, Muriate of Potash,	160 320 160	12.00	1486	17,832	2755	16,210
OO.	Nothing,	—	—	914	10,968	2057	12,100
X.	Stable Manure, Dis. Bone-black,	12000 160	18.80	1303	15,636	2685	15,790
Y.	Stable Manure,	16000	19.20	1474	16,688	2699	15,888

Table 43.

SOIL TEST WITH FERTILIZERS ON CORN.

By ELBERT MANCHESTER, Bristol.

Plot No.	Fertilizers per Acre. Kind.	Weight.	Cost.	Yield per Plot. (1-10 Acre.) Ears. Good.	Ears. Poor.	Stover.	Yield per Acre. Shelled Corn. (11 % Water) Good.	Shelled Corn. Poor.	Stover.	Gain or Loss (–) Over Nothing Plots.
		Lbs.	$	Lbs.	Lbs.	Lbs.	Bu.	Bu.	Lbs.	Bu.
0.	Nothing, - -	—	—	203	53	521	22.1	4.2	5210	—
A.	Nitrate of Soda, -	160	3.96	258	45	518	28.0	3.6	5180	0.4
B.	Dis. Bone-black, -	320	4.40	159	45	522	17.4	3.6	5220	–10.2
C.	Muriate of Potash, -	160	3.48	220	45	567	23.9	3.6	5670	–3.7
D.	Nitrate of Soda, - Dis. Bone-black, -	160 320	8.48	338	43	586	36.7	3.4	5860	8.9
E.	Nitrate of Soda, - Muriate of Potash, -	160 160	7.52	371	34	639	40.3	2.7	6390	11.8
F.	Dis. Bone-black, - Muriate of Potash, -	320 160	8.00	346	33	586	37.6	2.6	5860	9.0
G.	Nitrate of Soda, - Dis. Bone-black, - Muriate of Potash, -	160 320 160	12.00	344	32	705	37.4	2.6	7050	8.8
00.	Nothing, - -	—	—	304	37	564	33.0	3.0	5640	—

Table 44.

SOIL TEST WITH FERTILIZERS ON CORN.

By SPERRY BROTHERS, Bolton.

Plot No.	Fertilizers per Acre. Kind.	Weight.	Cost.	Yield per Plot. (1-10 Acre.) Ears. Good.	Ears. Poor.	Stover.	Yield per Acre. Shelled Corn. (11 % Water) Good.	Shelled Corn. Poor.	Stover.	Gain or Loss (–) Over Nothing Plots.
		Lbs.	$	Lbs.	Lbs.	Lbs.	Bu.	Bu.	Lbs.	Bu.
0.	Nothing, - -	—	—	217	22	203	24.4	2.3	2030	—
A.	Nitrate of Soda, -	160	3.96	194	21	204	21.8	2.2	2040	–5.4
B.	Dis. Bone-black, -	320	4.40	208	21	196	23.4	2.2	1960	–3.8
C.	Muriate of Potash, -	160	3.48	188	15	222	21.0	1.5	2220	–6.9
D.	Nitrate of Soda, - Dis. Bone-black, -	160 320	8.48	218	24	239	24.5	2.5	2390	–2.4
E.	Nitrate of Soda, - Muriate of Potash, -	160 160	7.52	229	20	246	25.7	2.1	2460	–1.6
F.	Dis. Bone-black, - Muriate of Potash, -	320 160	8.00	225	24	281	25.2	2.5	2810	–1.7
G.	Nitrate of Soda, - Dis. Bone-black, - Muriate of Potash, -	160 320 160	12.00	281	20	306	31.6	2.1	3060	4.3
H.	Plaster, - - -	400	1.70	269	21	244	30.2	2.2	2440	3.0
00.	Nothing, - -	—	—	258	29	262	29.0	3.0	2620	—

Table 45.
SOIL TEST WITH FERTILIZERS ON CORN.
By WM. E. ALVORD, Bolton.

Plot No.	Fertilizers per Acre.			Yield per Plot (1-10 Acre.)			Yield per Acre.			
	Kind.	Weight.	Cost.	Ears. Good.	Ears. Poor.	Stover.	Shelled Corn. 11 % Water. Good.	Shelled Corn. 11 % Water. Poor.	Stover.	Gain over Nothing Plots.
		Lbs.	$	Lbs.	Lbs.	Lbs.	Bu.	Bu.	Lbs.	Bu.
0.	Nothing, - -	—	—	239	26	263	27.5	2.7	2630	—
A.	Nitrate of Soda, -	160	3.96	291	19	290	33.4	1.9	2900	3.0
B.	Dis. Bone-black, -	320	4.40	274	17	273	31.5	1.7	2730	0.9
C.	Muriate of Potash, -	160	3.48	282	21	289	32.5	2.1	2890	2.3
D.	Nitrate of Soda, - Dis. Bone-black, -	160 320	8.48	309	22	290	35.5	2.2	2900	5.4
E.	Nitrate of Soda, - Muriate of Potash, -	160 160	7.52	297	27	305	34.1	2.8	3050	4.6
F.	Dis. Bone-black, - Muriate of Potash, -	320 160	8.00	313	25	331	36.0	2.6	3310	6.3
G.	Nitrate of Soda, - Dis. Bone-black, - Muriate of Potash, -	160 320 160	12.00	332	27	344	38.3	2.8	3440	7.8
H.	Plaster, - -	400	1.70	306	26	298	35.3	2.7	2980	5.7
00.	Nothing, - -	—	—	264	40	276	30.3	4.1	2760	—

Table 46.
SOIL TEST WITH FERTILIZERS ON CORN.
By C. H. LATHROP, North Franklin.

Plot No.	Fertilizers per Acre.			Yield per Plot (1-10 Acre.)			Yield per Acre.			
	Kind.	Weight.	Cost.	Ears. Good.	Ears. Poor.	Stover.	Shelled Corn 11 % Water. Good.	Shelled Corn 11 % Water. Poor.	Stover.	Gain or Loss (-) over N'thg Plts.
		Lbs.	$	Lbs.	Lbs.	Lbs.	Bu.	Bu.	Lbs.	Bu.
0.	Nothing, - -	—	—	241	26	229	27.4	2.9	2290	—
A.	Nitrate of Soda, -	160	3.96	164	44	180	18.6	4.5	1800	1.4
B.	Dis. Bone-black, -	320	4.40	199	31	197	22.6	3.2	1970	4.1
C.	Muriate of Potash, -	160	3.48	154	37	170	17.5	3.8	1700	-0.4
D.	Nitrate of Soda, - Dis. Bone-black, -	160 320	8.48	141	35	175	16.0	3.6	1750	-2.1
E.	Nitrate of Soda, - Muriate of Potash, -	160 160	7.52	116	43	161	13.2	4.4	1610	-4.1
F.	Dis. Bone-black, - Muriate of Potash, -	320 160	8.00	172	32	202	19.5	3.3	2020	1.1
G.	Nitrate of Soda, - Dis. Bone-black, - Muriate of Potash, -	160 320 160	12.00	147	31	182	16.7	3.2	1820	1.8
00.	Nothing, - -	—	—	77	42	133	8.8	4.3	1330	—

TABLE 47.

SOIL TEST WITH FERTILIZERS ON CORN.

BY C. A. SHARPE, ABINGTON.

Plot No.	Fertilizers per Acre. Kind.	Weight.	Cost.	Yield per Plot. (1-10 Acre.) Ears. Good.	Ears. Poor.	Stover.	Yield per Acre. Shelled Corn. (11% Water) Good.	Shelled Corn. Poor.	Stover.	Gain or Loss (-) Over Nothing Plots.
		Lbs.	$	Lbs.	Lbs.	Lbs.	Bu.	Bu.	Lbs.	Bu.
O.	Nothing,	—	—	48	25	156	5.9	2.7	1560	—
A.	Nitrate of Soda,	160	3.96	140	28	194	17.1	3.0	1940	14.4
B.	Dis. Bone-black,	320	4.40	27	10	160	3.3	1.1	1600	−1.3
C.	Muriate of Potash,	160	3.48	27	18	217	3.3	1.9	2170	−0.5
D.	Nitrate of Soda, Dis. Bone-black,	160 320	8.48	163	18	227	19.9	1.9	2270	16.1
E.	Nitrate of Soda, Muriate of Potash,	160 160	7.52	168	22	269	20.5	2.3	2690	17.1
F.	Dis. Bone-black, Muriate of Potash,	320 160	8.00	23	18	212	2.8	1.9	2120	−1.0
G.	Nitrate of Soda, Dis. Bone-black, Muriate of Potash,	160 320 160	12.00	132	22	269	16.1	2.3	2690	12.7
H.	Plaster,	400	1.70	14	19	153	1.7	2.0	1530	−2.0
OO.	Nothing,	—	—	8	17	148	1.0	1.8	1480	—

COMPOSITION OF NEW ENGLAND FEEDING STUFFS.

BY CHAS. D. WOODS.

The Reports of the Connecticut Experiment Station for 1888, and previously, have given compilations of the analyses of American feeding stuffs, by Dr. E. H. Jenkins. Experiment Station Bulletin No. 11 of the Office of Experiment Stations of the U. S. Department of Agriculture, contains a detailed compilation by Messrs. Jenkins and Winton of nearly all American analyses which were published before Sept. 1st, 1890. It includes "all the analyses of American feeding stuffs which were accessible to the compilers at the time the work was done, with the exception of those which were so incomplete or so obviously erroneous as to leave no doubt about the propriety of excluding them."

The coarse fodders used in New England are, for the most part, grown in New England. For the past few years this Station has collated for its own use the analyses of New England grown fodders. As we have found these averages to differ considerably from the averages of all American analyses, it has seemed wise to print our compilation.* A few words of explanation of terms, are given with the hope of making the table of analyses more easily understood.

Feeding stuffs are ordinarily divided into two classes: Coarse fodders, hay, stover, ensilage, etc., and concentrated feeds, as the

* The following averages of analyses of Hungarian hay illustrate the differences in composition referred to:

Hungarian Hay.	Water.	Protein.	Fat.	Nit.-free Ex't.	Fiber.	Ash.
	%	%	%	%	%	%
Average of compilations by Jenkins and Winton, - - - - -	7.7	7.5	2.1	49.0	27.7	6.0
Average of New England analyses, -	24.2	7.2	2.3	36.9	23.7	5.7

These differences in composition were largely due to water content, but that they were not entirely due to the different percentages of water is shown by the composition calculated to water-free substance as follows:

Hungarian Hay.	Protein.	Fat.	Nit.-free Ex't.	Fiber.	Ash.
	%	%	%	%	%
Average of compilations by Jenkins and Winton, - - - - - - - - -	8.1	2.3	53.1	30.0	6.5
Average of New England analyses, - -	9.6	3.0	48.8	31.1	7.5

grains, gluten and oil meals, wheat bran, etc. This distinction, which depends upon the mechanical condition of the feeding stuffs, while convenient, is arbitrary. It is generally believed that the coarse materials, such as hay, straw, etc., are essential for such animals as chew the cud and for horses. It is certainly of great importance that the coarse fodders of the farm should be profitably utilized, and it may be that the supposed necessity of this class of foods for ruminants is based more upon economical than upon physiological grounds. However this may be, the reason why any or all of the materials commonly used for food are so used, lies in the fact that, whatever their source or mechanical condition, they contain those classes of compounds which are essential for animal life, and consequently the production of milk, butter, beef, or work.

COMPOSITION OF FEEDING STUFFS.

The materials which we feed, so far from being simple in their structure, are composed of many different compounds, which, in the current methods of analysis, are more or less roughly grouped as water, protein, fats, carbohydrates and mineral matters or ash.

The water of a feeding stuff is of no more value for feeding purposes than other water, and hence should not be included among the nutrients or nutritive matter of food. It is quite a common belief among farmers that certain succulent foods such as potatoes, roots and green fodders are more valuable for being watery. A good many exact feeding experiments upon this subject have failed to show that these foods are more digestible and otherwise more valuable for making meat or milk, or for any other purpose of feeding, because of their large water content. Indeed, the presence of water in a food, instead of increasing, reduces the feeding value, since it decreases the amount of nutritive materials (nutrients). A feeding stuff which contains fifty per cent. of water will have only a little more than half the quantity of nutrients that the same material would furnish if the amount of water was reduced to ten per cent. In other words, the less water a feeding stuff contains, other things being equal, the higher will be its feeding value.

The nutrients proper, then, consist of the compounds grouped under protein, fat, carbohydrates, and mineral matters.

The protein consists in part of the albuminoids or albumen like substance, a familiar example of which is the gluten of

wheat. Besides the albuminoids proper, there are other nitrogenous compounds present in vegetable substances, such as the amides, which are less valuable for feeding purposes than are the true albuminoids.

The fat, or, more properly speaking, the "ether extract," includes a large class of compounds dissolved by ether in the analyses made in the laboratory. In addition to the fats or oils proper, the ether extract may contain wax, resins, chlorophyl (the green coloring matter of plants), besides several other less familiar compounds.

The carbohydrates include both the fiber and the "nitrogen-free extract." Fiber is the woody part of a plant, consisting principally of cellulose and lignin. Cellulose is the digestible part of the fiber and is much like starch in its chemical composition and probable feeding value.

The nitrogen-free extract is not directly determined in ordinary analyses, but is found by difference; that is, by subtracting the sum of the percentages of the other ingredients from one hundred per cent. It consists of starch, sugar, gums, and many other substances not so well known.

All the parts of plants contain more or less mineral matter or ash, and generally in more than sufficient amount for feeding purposes, and for this reason it is not usually taken into account in calculating rations. It is, however, of the utmost importance in the proper nutrition of an animal that the ash constituents be furnished in sufficient quantity.

USES OF THE FOOD.

The food supplies the needs of the body in several ways. It is used to form new tissues and fluids and to repair the wastes of the old; it is stored in the body in the form of fat; and it is consumed as fuel, its potential energy being transformed into heat or muscular energy, or other forms of energy required by the body.

It is only recently that we have learned to know in what way the various classes of nutrients of which the food materials are composed, are used in the body. While there is much that remains to be done before we shall have an exact knowledge of this subject, the following statements can be made with considerable certainty:

The protein forms tissues, as muscles, tendon, etc., and fat, and serves as fuel.

The fat forms fatty tissue, not muscle or tendon, and serves as fuel.

The carbohydrates serve as fuel and may be transformed into fat. The amount of carbohydrates which exist as such in the body is very minute, and it might seem as though they would be of very little feeding importance, but they are one of the principle sources of animal heat and of muscular power, and may be transformed into fat, and thus stored in the body for future use.

In supplying the body with fuel the protein, fat and carbohydrates replace each other in nearly exact proportions to their potential energy or fuel value, which is measured by the heat produced when they are burned.*

From experiment it has been found that each .01 pound of protein or carbohydrates yields, when burned, about 18.6 calories of potential energy, and that each .01 pound of fat yields 42.2 calories. In the compilation of analyses of feeding stuffs which follows, the fuel values of the different foods have been obtained by the use of these factors.

The table itself requires little explanation. "Maximum" and "Minimum" represent in each case the largest and the smallest percentage of each ingredient found in any specimen of the material named. Hence, they do not show the composition of any one specimen, but rather the extreme percentages of each ingredient determined in the different specimens analyzed. Of course, they do not foot up to 100 per cent., but those for minimum fall below, and those for the maximum rise above 100. These figures are given in order to indicate, so far as the data will allow, the variations in composition that may be expected in feeding stuffs.

The fuel values of one pound of each of the foods were calculated by the use of factors, as explained above.

The number of analyses of New England grown milling products is doubtless greater than given in the table herewith, but from the analyses as reported, it is in most cases impossible to distinguish between western grown and New England grown milling products. There is appended to the table the average composition of the more commonly fed American milling and waste products as compiled by Dr. Jenkins and Mr. Winton.†

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* See Report of this Station for 1890, p. 177.

† Experiment Station Bulletin, No. 11, Office of Experiment Stations, U. S. Department of Agriculture.

TABLE 48.

Minimum, Maximum and Average Composition of New England grown Feeding Stuffs and American Milling Products.

KIND.		No. of Analysis.	In Water-free Substance.						Calculated to Water Content at Time of Sampling.						
			Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.	Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.
Green Fodders, Grasses, Etc.			%	%	%	%	%		%	%	%	%	%	%	
Barley fodder, at cutting,	Min.,	2	12.1	2.4	34.6	19.9	8.3	1450	65.1	2.1	.4	5.8	4.3	2.9	245
	Max.,	2	13.7	2.5	55.6	25.7	25.2	1765	83.1	4.8	.9	19.4	6.9	4.3	615
	Avg.,	2	**12.9**	**2.4**	**45.1**	**22.8**	**16.8**	**1605**	**74.1**	**3.5**	**.6**	**12.6**	**5.6**	**3.6**	**430**
Hungarian, at cutting,	Min.,	9	6.9	1.7	41.9	28.4	4.3	1750	65.8	2.1	.5	9.1	7.6	1.2	435
	Max.,	9	17.1	4.1	51.8	34.7	9.8	1875	78.3	4.7	1.1	16.9	11.2	2.7	610
	Avg.,	9	**10.9**	**2.7**	**47.4**	**31.7**	**7.3**	**1790**	**72.3**	**3.0**	**.7**	**13.2**	**8.8**	**2.0**	**495**
Corn (maize) fodder, dent, at cutting,	Min.,	16	7.6	1.0	42.6	20.4	4.6	1730	70.5	.5	.1	3.0	2.0	.6	110
	Max.,	16	18.2	5.4	61.4	34.7	10.6	1875	39.6	3.8	1.6	18.8	11.0	2.5	645
	Avg.,	16	**12.0**	**3.2**	**50.5**	**27.0**	**7.3**	**1800**	**83.8**	**1.9**	**.5**	**8.5**	**4.2**	**1.1**	**295**
Corn (maize) fodder, flint, at cutting,	Min.,	34	7.6	1.7	44.8	17.4	3.8	1710	58.7	1.4	.3	4.3	2.1	.7	170
	Max.,	34	17.2	6.7	63.1	32.1	11.3	1865	90.9	4.0	1.7	19.7	13.0	4.7	745
	Avg.,	34	**10.7**	**3.4**	**53.6**	**25.9**	**6.4**	**1820**	**79.9**	**2.0**	**.7**	**10.8**	**5.3**	**1.3**	**365**
Corn (maize) fodder, sweet, at cutting,	Min.,	8	7.9	1.3	45.2	23.9	5.5	1665	80.8	.9	.1	3.2	1.9	.7	115
	Max.,	8	13.5	4.2	55.9	30.8	13.8	1820	92.9	2.2	.6	9.2	6.0	2.3	320
	Avg.,	8	**10.7**	**2.5**	**49.8**	**27.4**	**9.6**	**1740**	**86.5**	**1.4**	**.3**	**6.8**	**3.7**	**1.3**	**235**
Meadow fescue (*Festuca elatior*), at cutting,	Min.,	8	6.9	2.5	41.0	35.0	5.9	1785	69.9	1.8	.7	9.7	7.9	1.6	425
	Max.,	8	14.1	3.4	47.3	38.0	8.3	1810	76.3	3.3	.8	14.3	10.6	2.1	545
	Avg.,	8	**9.1**	**2.9**	**45.0**	**36.0**	**7.0**	**1800**	**73.3**	**2.4**	**.8**	**12.1**	**9.6**	**1.8**	**480**
Oat fodder, at cutting,	Min.,	2	7.1	2.0	50.4	32.8	7.0	1770	71.2	1.5	.4	10.8	7.1	1.6	380
	Max.,	2	7.1	2.4	50.7	33.1	7.4	1785	78.6	2.0	.7	14.6	9.5	2.0	515
	Avg.,	2	**7.1**	**2.2**	**50.6**	**32.9**	**7.2**	**1775**	**74.9**	**1.8**	**.5**	**12.7**	**8.3**	**1.8**	**450**

Avena elatior, at cutting, -	Min.,	4	7.4	3.1	42.8	32.5	7.1	1795	65.9	2.4	1.0	13.4	10.1	2.2	565
	Max.,	4	13.7	3.6	47.1	36.2	7.4	1810	69.0	4.3	1.1	16.1	11.9	2.4	615
	Avg.,	4	**9.9**	**3.4**	**45.0**	**34.5**	**7.2**	**1805**	**67.8**	**3.2**	**1.1**	**14.5**	**11.1**	**2.3**	**580**
Orchard grass, at cutting, -	Min.,	11	5.6	1.9	38.6	30.9	5.8	1780	65.3	1.7	.7	9.9	7.8	1.6	400
	Max.,	11	16.8	4.9	48.2	36.9	9.7	1820	77.8	4.0	1.8	15.5	12.6	3.2	625
	Avg.,	11	**9.4**	**3.9**	**44.4**	**34.1**	**8.2**	**1800**	**70.0**	**2.8**	**1.1**	**13.3**	**10.2**	**2.6**	**535**
Pearl millet, at cutting, - -	Min.,	4	7.6	.9	47.8	30.4	6.7	1750	62.4	1.9	.2	11.3	7.8	1.6	400
	Max.,	4	8.1	2.6	52.0	34.3	8.8	1785	77.2	2.9	1.0	19.5	11.4	2.8	670
	Avg.,	4	**7.9**	**1.8**	**49.8**	**33.0**	**7.5**	**1765**	**72.5**	**2.2**	**.5**	**13.7**	**9.0**	**2.1**	**485**
Red-top, at cutting, - -	Min.,	5	5.0	2.2	48.0	32.8	5.2	1775	57.3	2.0	.6	11.7	8.0	1.7	425
	Max.,	5	9.7	2.7	50.9	36.9	7.3	1800	76.2	2.8	1.0	21.6	15.7	2.9	775
	Avg.,	5	**7.3**	**2.4**	**49.7**	**34.2**	**6.4**	**1795**	**65.9**	**2.3**	**.8**	**17.1**	**11.7**	**2.2**	**610**
Rye fodder, at cutting, - -	Min.,	2	8.3	2.4	40.1	25.8	6.2	1775	74.7	1.6	.7	5.1	3.3	.6	225
	Max.,	2	17.4	5.3	44.4	38.8	11.5	1805	87.3	2.2	2.1	9.8	11.2	1.4	510
	Avg.,	2	**12.8**	**3.9**	**42.2**	**32.3**	**8.8**	**1790**	**81.0**	**1.9**	**1.4**	**7.5**	**7.2**	**1.0**	**370**
Sweet vernal grass, at cutting,	Min.,	2	8.9	3.3	48.1	30.0	5.9	1830	74.4	2.3	.8	12.0	7.7	1.5	455
	Max.,	2	11.6	3.8	51.2	31.1	6.1	1835	75.1	2.9	1.0	13.1	7.7	1.5	470
	Avg.,	2	**10.3**	**3.5**	**49.6**	**30.6**	**6.0**	**1740**	**74.7**	**2.6**	**.9**	**12.6**	**7.7**	**1.5**	**465**
Tall oat grass, at cutting, -	Min.,	2	6.4	2.2	48.9	34.8	5.8	1805	72.6	1.7	.6	13.0	9.2	1.6	475
	Max.,	2	8.0	2.4	50.1	35.5	5.9	1805	73.5	2.1	.6	13.8	9.7	1.6	495
	Avg.,	2	**7.2**	**2.3**	**49.5**	**35.2**	**5.8**	**1805**	**73.0**	**1.9**	**.6**	**13.4**	**9.5**	**1.6**	**485**
Timothy, at cutting, - -	Min.,	19	5.5	1.8	45.8	28.7	3.7	1785	55.3	2.1	.7	10.5	6.1	1.4	385
	Max.,	19	11.9	3.8	53.3	39.7	7.5	1825	78.7	3.7	1.1	23.3	13.6	2.2	825
	Avg.,	19	**8.4**	**2.7**	**49.3**	**33.7**	**5.9**	**1815**	**68.2**	**2.6**	**.8**	**15.8**	**10.8**	**1.8**	**575**
Wheat fodder, at cutting, -	Min.,	4	8.5	3.4	43.7	26.4	5.4	1830	69.9	2.2	.9	10.1	6.3	1.5	425
	Max.,	4	12.3	3.8	52.5	34.9	6.6	1840	76.8	3.7	1.0	14.8	9.0	1.6	550
	Avg.,	4	**10,6**	**3.7**	**48.8**	**30.7**	**6.2**	**1835**	**74.3**	**2.8**	**.9**	**12.6**	**7.9**	**1.5**	**470**
Yellow oat grass, at cutting, -	Min.,	2	6.4	2.3	51.7	33.7	4.1	1815	66.7	1.9	.7	15.5	10.1	1.4	540
	Max.,	2	7.7	2.5	51.7	34.2	5.7	1840	70.1	2.5	.8	17.2	11.4	1.7	615
	Avg.,	2	**7.1**	**2.4**	**51.7**	**33.9**	**4.9**	**1825**	**68.4**	**2.2**	**.8**	**16.8**	**10.3**	**1.5**	**580**
Green Fodders (Legumes).															
Clover, red, at cutting, - -	Min.,	10	10.4	1.7	38.4	22.5	6.5	1720	47.1	2.3	.4	5.3	2.5	1.3	250
	Max.,	10	20.1	4.7	49.0	31.8	10.7	1840	86.8	7.1	1.4	25.8	14.7	4.0	550
	Avg.,	10	**16.0**	**2.8**	**44.4**	**28.2**	**8.6**	**1765**	**78.6**	**3.9**	**.8**	**9,0**	**5.7**	**2.0**	**380**

TABLE 48.—*(Continued.)*

Kind.		No. of Analysis.	In Water-free Substance. Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.	Calculated to Water Content at Time of Sampling. Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.
			%	%	%	%	%		%	%	%	%	%	%	
Green Fodders (Legumes). (Continued.)															
Cow pea fodder, at cutting,	Min.,	25	8.3	1.8	35.0	19.9	6.0	1645	78.8	1.7	.3	4.1	3.1	1.2	200
	Max.,	25	21.7	4.6	60.9	27.6	15.1	1755	88.3	3.5	.7	12.9	5.1	2.7	390
	Avg.,	25	**17.5**	**3.2**	**45.4**	**22.5**	**11.4**	**1725**	**83.0**	**2.9**	**.6**	**7.8**	**3.8**	**1.9**	**295**
Oat and pea fodder at cutting,	Min.,	5	13 1	2.7	38.4	24.1	8.1	1755	72.9	3.0	.6	5.9	3.7	1.4	285
	Max.,	5	22.9	5.1	44.9	31.2	9.9	1805	84.7	3.5	1.0	12.2	7.7	2.7	475
	Avg.,	5	**17.8**	**3.9**	**41.7**	**27.5**	**9.1**	**1785**	**80.3**	**3.4**	**.7**	**8.3**	**5.5**	**1.8**	**350**
Serradella, at cutting,	Min.,	3	12.0	2.1	35.4	26.2	11.5	1695	80.1	2.3	.4	6.4	4.1	1.8	260
	Max.,	3	17.8	2.7	41.4	38.8	11 9	1700	84.6	2.7	.4	7.1	7.7	2.3	335
	Avg.,	3	**14.0**	**2.3**	**37.5**	**34.6**	**11.6**	**1700**	**81.7**	**2.5**	**.4**	**6.8**	**6.5**	**2.1**	**310**
Soy bean *(Soja hispida)* fodder, at cutting,	Min.,	6	8.8	2.5	40.8	19.8	6.4	1740	72.2	2.3	.6	10.7	5.2	1.8	410
	Max.,	6	20.7	8.5	55.4	31.7	11.1	1870	76 8	5.4	2.2	14.3	8.8	2.8	505
	Avg.,	6	**13.2**	**4.4**	**46.4**	**26.9**	**9.1**	**1795**	**74.4**	**3.4**	**1.1**	**11.9**	**6.9**	**2.3**	**460**
Vetch fodder, at cutting,	Min.,	3	19.0	1.9	31.6	28.8	9.6	1555	78.2	3.8	.4	5.9	5.0	1 6	390
	Max.,	3	22.6	2.3	35.4	31.7	18.8	1735	83.3	4.1	.4	6.9	6.3	4.1	340
	Avg.,	3	**20.7**	**2.1**	**33.2**	**30.2**	**13.8**	**1650**	**81.0**	**3.9**	**.4**	**6.3**	**5.7**	**2.7**	**305**
Vetch and oat fodder, at cutting,	Min.,	7	7.7	2.3	40.1	26.3	7.2	1695	64.8	1.5	.4	5 6	4.7	1.5	235
	Max.,	7	14.8	4.8	50.0	35.7	12.4	1835	86.1	3.6	.9	17.6	10.8	3.3	625
	Avg.,	7	**10.8**	**3.0**	**44.8**	**32.4**	**9.0**	**1765**	**76.2**	**2.6**	**.7**	**10.8**	**7.6**	**2.1**	**400**
Cured Fodders, Grasses, Etc. (Hays).															
Blue (June) grass *(Poa pratensis)* cured,	Min.,	3	8 8	2.0	43.5	29.6	6.7	1750	6.6	8.2	1.9	39.3	26.8	6.3	1635
	Max.,	3	15.4	4.5	44.9	36.8	8.2	1835	9.6	13.9	4.1	41.9	34.3	7.7	1710
	Avg.,	3	**12.4**	**3.5**	**44.2**	**32.6**	**7.3**	**1805**	**7.7**	**11.4**	**3.3**	**40.7**	**30.1**	**6.8**	**1670**

Bromus,	Min.,	2	10.6	3.6	49.0	28.2	6.8	1805	8.4	9.6	3.3	44.8	25.6	6.2	1635
	Max.,	2	11.0	3.8	49.5	29.7	7.9	1820	9.3	10.1	3.4	44.9	27.2	7.2	1665
	Avg.,	2	**10.8**	**3.7**	**49.2**	**29.0**	**7.3**	**1815**	**8.8**	**9.8**	**3.4**	**44.9**	**26.4**	**6.7**	**1650**
Corn fodder, field cured,	Min.,	5	5.9	2.0	58.8	21.1	2.9	1815	24.4	2.9	1.2	24.5	8.4	1.7	735
	Max.,	5	10.1	3.1	61.7	28.3	5.1	1865	60.2	6.2	2.0	46.4	21.1	3.8	1410
	Avg.,	5	**8.4**	**2.5**	**60.5**	**24.3**	**4.3**	**1840**	**39.5**	**5.1**	**1.5**	**36.6**	**14.8**	**2.5**	**1115**
Corn fodder,	Min.,	5	6.2	1.1	53.9	23.0	4.7	1800	6.6	5.8	1.0	47.5	20.9	4.4	1635
	Max.,	5	9.3	2.8	58.9	33.0	6.0	1815	14.8	8.4	2.5	53.4	31.5	5.4	1685
	Avg.,	5	**7.5**	**1.8**	**56.0**	**29.5**	**5.2**	**1805**	**9.3**	**6.9**	**1.6**	**50.7**	**26.8**	**4.7**	**1640**
Corn stover,	Min.,	10	4.7	1.3	49.0	32.4	5.9	1755	5.5	3.9	1.0	33.3	22.6	4.3	1220
	Max.,	10	9.2	2.7	52.2	36.8	7.8	1815	31.9	6.5	2.2	49.4	31.8	7.2	1690
	Avg.,	10	**6.2**	**2.1**	**50.7**	**34.2**	**6.8**	**1785**	**18.2**	**5.1**	**1.7**	**41.5**	**27.9**	**5.6**	**1460**
Corn stover, field cured,	Min.,	163	3.7	1.2	44.7	20.9	3.7	1715	15.4	1.7	.5	13.8	9.1	1.9	515
	Max.,	163	11.3	3.4	63.1	39.2	9.5	1835	71.3	7.8	2.2	53.3	32.2	6.8	1560
	Avg.,	163	**6.5**	**1.8**	**51.6**	**33.9**	**6.2**	**1785**	**45.6**	**3.5**	**1.0**	**28.1**	**18.5**	**3.3**	**790**
Fescue grass (*Festuca elatior*),	Min.,	2	7.5	2.9	50.7	28.7	6.3	1800	11.1	6.7	2.5	44.1	24.9	5.6	1565
	Max.,	2	10.9	3.0	51.8	31.3	6.9	1815	13.0	9.5	2.7	46.1	27.8	6.0	1610
	Avg.,	2	**9.2**	**3.0**	**51.2**	**30.0**	**6.6**	**1810**	**12.0**	**8.1**	**2.6**	**45.1**	**26.4**	**5.8**	**1590**
Fowl meadow grass (*Poa serotina*), hay,	Min.,	3	8.7	2.8	42.3	31.7	7.4	1760	10.4	7.3	2.5	37.7	28.2	6.1	1515
	Max.,	3	14.9	4.0	46.2	33.8	9.5	1820	16.5	13.3	3.3	38.6	29.3	8.5	1585
	Avg.,	3	**11.9**	**3.4**	**43.6**	**32.7**	**8.4**	**1785**	**12.6**	**10.5**	**2.9**	**38.0**	**28.6**	**7.4**	**1550**
Hungarian grass,	Min.,	20	5.8	1.7	41.9	29.2	5.1	1745	7.0	5.2	1.5	29.5	19.4	4.6	1160
	Max.,	20	14.2	3.8	53.0	34.7	8.6	1825	34.9	11.3	3.1	48.0	30.7	7.6	1680
	Avg.,	20	**9.6**	**3.0**	**48.8**	**31.1**	**7.5**	**1790**	**24.2**	**7.2**	**2.3**	**36.9**	**23.7**	**5.7**	**1360**
Italian rye grass,	Min.,	4	6.2	1.4	43.1	31.3	6.6	1755	7.4	5.7	1.3	39.6	28.4	6.1	1605
	Max.,	4	9.8	2.0	52.8	36.9	8.6	1770	9.3	8.8	1.9	48.9	33.9	7.9	1655
	Avg.,	4	**8.2**	**1.8**	**49.1**	**33.4**	**7.5**	**1765**	**8.5**	**7.4**	**1.7**	**45.2**	**30.3**	**6.9**	**1615**
Meadow fescue,	Min.,	4	7.0	1.8	42.0	34.1	7.2	1750	5.3	6.4	1.6	38.3	28.3	6.4	1510
	Max.,	4	7.9	4.4	49.2	39.7	8.5	1820	16.9	7.5	3.7	45.5	37.5	8.0	1660
	Avg.,	4	**7.4**	**2.6**	**46.4**	**35.7**	**7.9**	**1775**	**9.4**	**6.8**	**2.3**	**42.0**	**32.4**	**7.1**	**1605**
Mixed hay (from mixed grasses),	Min.,	17	6.5	2.0	43.5	27.4	4.1	1800	6.1	5.9	1.9	38.1	23.2	3.6	1420
	Max.,	17	11.9	4.4	56.0	39.7	8.1	1835	21.4	10.4	3.8	50.8	34.7	7.1	1720
	Avg.,	17	**9.0**	**3.3**	**50.8**	**30.7**	**6.2**	**1825**	**13.7**	**7.7**	**2.9**	**44.2**	**26.1**	**5.4**	**1575**

TABLE 48.—(*Continued.*)

Kind.		No. of Analysis.	In Water-free Substance.						Calculated to Water Content at Time of Sampling.						
			Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.	Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.
Cured Fodders, Grasses, Etc. (Hays). *(Continued.)*			%	%	%	%	%		%	%	%	%	%	%	
Mixed hay (from mixed grasses), field cured,	Min.,	46	6.4	3.0	46.5	31.1	4.3	1815	16.1	4.7	2.2	33.3	20.6	3.4	1245
	Max.,	46	10.9	5.9	54.6	34.9	6.6	1900	33.1	9.0	4.5	43.1	28.4	5.5	1545
	Avg.,	46	**8.2**	**3.7**	**49.9**	**32.9**	**5.3**	**1850**	**24.7**	**6.2**	**2.7**	**37.7**	**24.7**	**4.0**	**1390**
Oat hay,	Min.,	8	6.1	2.4	42.0	20.6	4.8	1790	6.2	5.5	2.1	36.2	15.1	3.5	1375
	Max.,	8	11.6	4.9	58.2	39.0	7.7	1880	26.9	9.9	4.6	53.4	33.6	6.6	1740
	Avg.,	8	**8.7**	**3.3**	**49.8**	**31.9**	**6.3**	**1820**	**12.6**	**7.7**	**2.8**	**43.4**	**28.0**	**5.5**	**1590**
Oat straw,	Min.,	3	2.6	1.2	30.1	41.9	2.1	1850	10.0	2.3	1.0	26.4	37.8	1.8	1615
	Max.,	3	4.0	3.4	46.6	64.0	4.1	1865	12.5	3.5	3.0	42.0	56.8	3.7	1675
	Avg.,	3	**3.1**	**1.9**	**35.6**	**56.6**	**2.8**	**1855**	**11.3**	**2.7**	**1.7**	**31.7**	**50.2**	**2.4**	**1645**
Oat straw, field cured,	Min.,	26	3.7	2.4	43.6	34.5	4.1	1810	10.4	3.2	2.0	30.0	28.0	3.5	1225
	Max.,	26	9.0	3.9	49.6	43.2	6.3	1865	32.4	7.7	3.5	43.5	36.8	5.3	1670
	Avg.,	26	**5.7**	**3.1**	**47.0**	**39.1**	**5.1**	**1840**	**15.2**	**4.8**	**2.7**	**39.8**	**33.2**	**4.3**	**1560**
Oat grass (*Avena elatior*),	Min.,	2	10.5	3.1	44.0	33.3	7.5	1795	10.3	9.4	2.7	39.4	29.9	6.7	1600
	Max.,	2	11.9	3.3	44.9	34.1	7.5	1800	10.7	10.7	3.0	40.1	30.4	6.7	1615
	Avg.,	2	**11.2**	**3.2**	**44.4**	**33.7**	**7.5**	**1795**	**10.5**	**10.0**	**2.9**	**39.7**	**30.2**	**6.7**	**1610**
Orchard grass,	Min.,	13	7.6	2.4	38.3	24.9	7.0	1755	7.4	6.9	2.1	35.3	21.4	5.0	1505
	Max.,	13	15.5	5.5	54.8	37.1	9.8	1820	16.6	14.3	5.1	47.0	33.0	9.0	1675
	Avg.,	13	**9.7**	**3.8**	**45.6**	**32.8**	**8.1**	**1800**	**10.5**	**8.7**	**3.4**	**40.8**	**29.3**	**7.3**	**1610**
Pearl millet,	Min.,	2	7.9	.9	49.6	34.3	6.7	1750	7.8	7.3	.8	45.6	31.5	6.2	1610
	Max.,	2	8.1	1.5	49.6	34.3	7.1	1770	8.1	7.5	1.4	45.7	31.6	6.5	1635
	Avg.,	2	**8.0**	**1.2**	**49.6**	**34.3**	**6.9**	**1760**	**7.9**	**7.4**	**1.1**	**45.7**	**31.5**	**6.4**	**1625**

Red-top (*Agrostis vulgaris*)	Min.,	15	6.4	1.5	46.7	26.9	4.2	1780	5.6	5.9	1.4	38.2	24.9	3.8	1495
	Max.,	15	13.3	4.8	54.7	34.1	8.3	1860	18.1	12.3	4.0	50.4	31.8	7.7	1715
	Avg.,	15	**9.0**	**3.1**	**50.7**	**30.9**	**6.3**	**1815**	**9.9**	**8.1**	**2.8**	**45.7**	**27.8**	**5.7**	**1635**
Rye straw	Min.,	3	2.4	1.1	40.8	39.1	3.1	1760	9.7	2.2	1.0	35.7	34.2	2.8	1540
	Max.,	3	7.9	3.0	45.5	47.9	9.2	1830	12.5	7.0	2.7	41.0	43.3	8.1	1650
	Avg.,	3	**6.1**	**2.4**	**42.4**	**42.0**	**7.1**	**1785**	**11.2**	**5.4**	**2.1**	**37.6**	**37.4**	**6.3**	**1585**
Rye grass	Min.,	2	10.9	2.7	48.7	27.5	8.1	1775	10.8	9.7	2.4	43.3	24.6	7.2	1580
	Max.,	2	12.6	2.9	50.8	27.7	8.1	1775	11.0	11.2	2.6	45.3	24.7	7.2	1585
	Avg.,	2	**11.8**	**2.8**	**49.7**	**27.6**	**8.1**	**1775**	**10.9**	**10.5**	**2.5**	**44.3**	**24.6**	**7.2**	**1585**
Timothy hay	Min.,	37	5.0	1.3	43.7	29.1	3.7	1795	6.7	4.1	1.1	37.8	24.1	3.3	1445
	Max.,	37	10.7	5.8	56.2	38.5	7.1	1895	22.1	9.7	4.6	51.1	35.8	6.3	1735
	Avg.,	37	**7.4**	**3.0**	**51.6**	**33.0**	**5.0**	**1840**	**10.8**	**6.7**	**2.7**	**45.8**	**29.5**	**4.5**	**1640**
Timothy and red-top	Min.,	16	6.5	1.7	45.7	28.8	4.0	1795	8.4	5.0	1.5	39.2	24.7	3.5	1025
	Max.,	16	10.5	3.6	54.7	34.5	8.0	1850	18.9	9.0	3.3	46.9	31.1	6.9	1695
	Avg.,	16	**8.5**	**2.9**	**50.4**	**32.5**	**5.7**	**1825**	**13.5**	**7.4**	**2.5**	**43.6**	**28.1**	**4.9**	**1575**
Cured Fodders (Legumes).															
Alfalfa	Min.,	8	11.1	1.1	40.1	25.4	7.1	1740	4.6	10.2	1.1	34.3	21.4	6.6	1450
	Max.,	8	18.8	4.5	51.7	34.4	10.5	1810	17.7	16.9	3.7	47.3	32.8	8.8	1675
	Avg.,	8	**14.8**	**2.2**	**44.2**	**30.5**	**8.3**	**1755**	**10.3**	**13.3**	**1.9**	**39.6**	**27.5**	**7.4**	**1575**
Clover (alsike)	Min.,	6	12.2	2.2	40.7	21.4	7.1	1670	8.3	10.5	2.0	35.6	19.7	6.4	1555
	Max.,	6	17.3	4.2	48.2	31.9	13.4	1825	13.9	15.9	3.9	41.5	28.0	12.2	1670
	Avg.,	6	**14.9**	**3.4**	**44.1**	**27.5**	**10.1**	**1755**	**10.3**	**13.4**	**3.0**	**39.6**	**24.6**	**9.1**	**1570**
Clover (red)	Min.,	10	10.4	1.7	38.8	20.2	6.5	1705	5.1	9.5	1.6	32.0	18.3	6.1	1415
	Max.,	10	18.5	4.6	49.7	33.7	10.5	1810	17.5	16.8	4.3	45.8	29.3	9.5	1655
	Avg.,	10	**14.5**	**2.3**	**45.7**	**28.9**	**8.6**	**1755**	**8.3**	**13.3**	**2.2**	**41.9**	**26.5**	**7.8**	**1610**
Oat and pea hay	Min.,	2	10.8	3.4	44.2	30.8	7.3	1785	16.7	9.0	2.8	36.8	25.5	6.0	1485
	Max.,	2	12.4	4.9	46.8	31.3	8.2	1840	16.9	10.3	4.1	38.9	26.1	6.8	1535
	Avg.,	2	**11.6**	**4.2**	**45.5**	**31.0**	**7.7**	**1815**	**16.8**	**9.7**	**3.4**	**37.9**	**25.8**	**6.4**	**1510**
Rowen	Min.,	8	13.5	3.6	43.7	26.1	5.9	1810	13.4	11.6	3.1	35.1	21.2	5.1	1430
	Max.,	8	17.4	4.5	47.0	29.3	8.3	1835	21.6	14.8	3.5	40.0	25.2	7.1	1585
	Avg.,	8	**16.1**	**3.9**	**44.9**	**28.0**	**7.1**	**1820**	**15.3**	**13.6**	**3.3**	**38.1**	**23.7**	**6.0**	**1540**
Serradella hay	Min.,	3	15.3	2.4	45.8	21.9	5.9	1720	7.2	13.9	2.2	40.5	19.4	5.4	1520
	Max.,	3	17.8	3.3	50.2	25.1	11.7	1805	11.7	16.6	2.9	46.0	22.9	10.3	1675
	Avg.,	3	**16.8**	**2.9**	**48.5**	**23.8**	**8.0**	**1780**	**9.2**	**15.2**	**2.6**	**44.2**	**21.6**	**7.2**	**1615**

TABLE 48.—(*Continued.*)

Kind.		No. of Analysis.	In Water-free Substance.						Calculated to Water Content at Time of Sampling.						
			Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.	Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.
Cured Fodders (Legumes). (Continued).			%	%	%	%	%		%	%	%	%	%	%	
Vetch hay, - - - - -	Min.,	5	14.4	1.9	31.5	22.3	6.6	1650	8.3	13.1	1.6	26.5	19.7	7.1	1385
	Max.,	5	26.2	3.4	44.3	30.9	13.8	1820	15.8	23.1	3.0	40.2	28.1	11.6	1620
	Avg.,	5	**19.3**	**2.6**	**40.5**	**28.7**	**8.9**	**1755**	**11.3**	**17.0**	**2.3**	**36.1**	**25.4**	**7.9**	**1555**
Vetch and oat hay, - - -	Min.,	2	11.8	2.8	42.1	34.4	7.7	1775	11.8	10.4	2.3	35.2	28.8	6.8	1110
	Max.,	2	12.6	3.0	43.1	34.4	8.2	1790	16.4	10.5	2.6	38.0	30.4	6.8	1200
	Avg.,	2	**12.2**	**2.9**	**42.6**	**34.4**	**7.9**	**1785**	**14.1**	**10.5**	**2.4**	**36.6**	**29.6**	**6.8**	**1155**
Ensilage.															
Corn (maize) ensilage, - - -	Min.,	7	6.1	2.8	46.5	26.1	5.7	1790	61.6	1.1	.5	7.6	4.5	.9	295
	Max.,	7	10.7	4.3	57.7	33.0	7.4	1855	84.0	2.3	1.1	22.2	10.4	2.4	695
	Avg.,	7	**8.4**	**3.5**	**52.0**	**29.7**	**6.4**	**1825**	**79.5**	**1.7**	**.7**	**10.8**	**6.0**	**1.3**	**375**
Seeds, Grains, Etc.															
Barley grain, - - - -	Min.,	2	9.7	1.7	76.9	4.7	3.0	1840	10.3	8.6	1.5	68.9	4.1	2.7	1615
	Max.,	2	13.6	1.8	80.5	4.7	3.4	1845	11.9	12.3	1.6	70.9	4.2	3.0	1655
	Avg.,	2	**11.6**	**1.8**	**78.7**	**4.7**	**3.2**	**1845**	**11.1**	**10.5**	**1.5**	**69.9**	**4.2**	**2.8**	**1635**
Buckwheat grain, - - - -	Min.,	4	10.1	2.4	73.2	9.1	1.8	1870	11.4	8.6	2.1	64.5	7.8	1.5	1595
	Max.,	4	11.5	2.6	75.7	10.6	2.7	1880	14.8	10.2	2.3	64.9	9.4	2.3	1660
	Avg.,	4	**10.7**	**2.5**	**74.5**	**9.9**	**2.4**	**1875**	**13.1**	**9.4**	**2.2**	**64.7**	**8.6**	**2.0**	**1630**
Corn (maize) grain, sweet, - -	Min.,	11	12.5	4.3	68.8	1.7	1.7	1920	6.3	11.1	3.8	61.8	1.6	1.6	1710
	Max.,	11	17.0	10.1	78.3	3.0	2.4	2055	10.9	15.3	9.2	68.9	2.8	2.2	1935
	Avg.,	11	**14.4**	**8.6**	**72.4**	**2.5**	**2.1**	**2025**	**9.2**	**13.1**	**7.8**	**65.7**	**2.3**	**1.9**	**1835**

Corn (maize) grain, white flint,	Min.,	10	12.4	5.2	76.9	1.4	1.5	1950	7.5	11.4	4.8	70.0	1.3	1.4	1780
	Max.,	10	14.4	6.3	78.9	1.7	1.7	1975	9.3	13.1	5.8	73.0	1.5	1.6	1815
	Avg.,	10	**13.2**	**5.6**	**78.1**	**1.5**	**1.6**	**1960**	**8.6**	**12.0**	**5.2**	**71.3**	**1.4**	**1.5**	**1795**
Corn (maize) grain, yellow dent,	Min.,	9	9.9	4.4	77.7	1.5	1.5	1935	9.6	8.3	3.8	69.8	1.3	1.3	1640
	Max.,	9	12.9	5.8	82.3	2.4	2.0	1970	15.2	11.6	5.1	73.4	2.2	1.8	1760
	Avg.,	9	**11.3**	**5.0**	**80.2**	**1.8**	**1.7**	**1945**	**10.8**	**10.1**	**4.4**	**71.5**	**1.7**	**1.5**	**1735**
Corn (maize) grain, yellow dent, field cured,	Min.,	28	6.9	4.3	77.9	1.0	1.1	1920	20.3	4.4	1.8	33.5	.6	.7	815
	Max.,	28	12.8	5.8	85.1	2.7	2.2	1975	57.5	8.6	4.6	66.8	1.8	1.3	1570
	Avg.,	28	**10.0**	**5.4**	**81.5**	**1.7**	**1.4**	**1960**	**35.0**	**6.5**	**3.5**	**53.0**	**1.1**	**.9**	**1275**
Corn (maize) grain, yellow flint, unmerchantable corn (nubbins),	Min.,	10	11.5	3.9	77.0	1.5	1.4	1920	6.1	10.6	3.6	66.0	1.4	1.3	1685
	Max.,	10	13.4	6.5	80.8	2.3	2.4	1970	14.2	12.3	5.5	75.6	2.2	2.1	1825
	Avg.,	10	**12.4**	**4.9**	**79.3**	**1.7**	**1.7**	**1945**	**9.1**	**11.3**	**4.4**	**72.1**	**1.6**	**1.5**	**1765**
Corn (maize) grain, yellow flint,	Min.,	86	8.9	3.8	75.5	.9	1.2	1930	4.5	7.9	3.4	64.9	.8	1.0	1570
	Max.,	86	15.3	7.9	82.6	2.8	2.1	2010	19.6	13.7	7.1	76.7	2.5	1.8	1865
	Avg.,	86	**11.8**	**5.5**	**79.5**	**1.6**	**1.6**	**2015**	**10.2**	**10.6**	**4.9**	**71.4**	**1.4**	**1.5**	**1760**
Corn (maize) grain, yellow flint, field cured,	Min.,	106	7.6	4.1	77.1	1.0	.9	1745	20.4	5.3	2.3	43.7	.7	.6	1050
	Max.,	106	14.4	7.2	84.2	2.4	2.3	1990	46.0	10.5	5.3	65.1	1.7	1.6	1560
	Avg.,	106	**10.7**	**5.3**	**80.7**	**1.7**	**1.6**	**1955**	**29.0**	**7.6**	**3.8**	**57.2**	**1.2**	**1.2**	**1230**
Oats, grain,	Min.,	9	9.1	4.9	67.3	9.9	2.9	1905	9.3	8.0	4.4	59.0	8.9	2.6	1685
	Max.,	9	13.4	6.4	70.8	14.7	4.0	1955	13.5	12.1	5.8	63.2	12.9	3.5	1770
	Avg.,	9	**11.1**	**5.7**	**68.8**	**11.0**	**3.4**	**1930**	**10.8**	**9.8**	**5.1**	**61.4**	**9.9**	**3.0**	**1725**
Oats, grain, field cured,	Min.,	38	13.1	5.2	62.4	6.1	2.7	1830	11.2	11.2	4.5	52.7	5.3	2.2	1475
	Max.,	38	17.2	6.6	68.3	16.0	3.7	1960	18.5	14.9	5.7	60.3	13.6	3.2	1715
	Avg.,	38	**15.2**	**5.9**	**65.7**	**10.1**	**3.1**	**1940**	**14.0**	**13.0**	**5.1**	**56.5**	**8.7**	**2.7**	**1670**
Peas, seed,	Min.,	4	26.9	1.3	57.0	2.9	2.7	1830	11.5	23.5	1.1	50.4	2.5	2.4	1575
	Max.,	4	32.7	2.4	65.9	6.8	3.5	1855	13.7	28.6	2.1	57.7	6.0	3.3	1630
	Avg.,	4	**29.9**	**1.8**	**60.9**	**4.2**	**3.2**	**1845**	**12.6**	**26.2**	**1.5**	**53.2**	**3.6**	**2.9**	**1605**
Milling Products, Etc.															
Buckwheat middlings,	Min.,	4	27.4	6.9	55.8	2.3	4.7	1930	12.6	23.8	6.0	48.4	2.1	4.1	1685
	Max.,	4	28.9	7.4	58.1	3.3	5.0	1945	13.2	25.2	6.4	50.6	2.9	4.4	1695
	Avg.,	4	**28.3**	**7.1**	**56.8**	**2.9**	**4.9**	**1940**	**12.8**	**24.7**	**6.2**	**49.5**	**2.6**	**4.2**	**1690**
Corn (maize) meal,	Min.,	2	11.1	4.5	80.2	1.9	1.5	1935	11.4	1.2	0.1	47.7	2.3	1.3	1625
	Max.,	2	11.6	5.0	80.4	2.2	1.6	1950	15.0	10.3	5.2	69.1	38.3	2.0	1700
	Avg.,	2	**11.4**	**4.7**	**80.3**	**2.0**	**1.6**	**1945**	**13.6**	**7.1**	**3.7**	**62.1**	**11.8**	**1.7**	**1665**

TABLE 48.—*(Continued.)*

Kind.		No. of Analysis.	In Water-free Substance. Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.	Calculated to Water Content at Time of Sampling. Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.
Milling Products, Etc. *(Continued.)*			%	%	%	%	%		%	%	%	%	%	%	
Corn (maize) and cob meal,	Min.,	2	9.9	4.1	75.7	3.3	1.6	1925	11.8	8.6	3.6	65.3	2.9	1.4	1665
	Max.,	2	10.0	4.6	80.5	8.6	1.7	1940	13.7	8.8	4.1	71.0	7.4	1.4	1715
	Avg.,	2	**10.0**	**4.3**	**78.0**	**6.0**	**1.7**	**1935**	**12.8**	**8.7**	**3.8**	**68.1**	**5.2**	**1.4**	**1690**
Corn (maize) cob,	Min.,	4	1.4	.1	53.8	2.6	1.5	1835	14.5	9.5	3.7	67.1	1.6	1.3	1620
	Max.,	4	12.0	6.0	80.1	43.2	2.4	1965	16.3	9.7	4.3	68.8	1.8	1.4	1670
	Avg.,	4	**8.3**	**4.3**	**72.0**	**13.4**	**2.0**	**1924**	**15.4**	**9.6**	**4.0**	**68.0**	**1.7**	**1.3**	**1645**
Roots, Gourds, Tubers, Etc.															
Beets, red,	Min.,	7	7.8	.6	49.1	4.5	5.8	1640	85.5	1.1	.1	3.8	.6	.7	130
	Max.,	7	19.9	2.5	79.8	13.6	14.9	1780	92.2	1.7	.2	11.3	1.1	1.4	250
	Avg.,	7	**13.7**	**1.1**	**68.6**	**7.3**	**9.3**	**1715**	**88.5**	**1.5**	**.1**	**8.1**	**.8**	**1.0**	**200**
Beets, sugar,	Min.,	15	7.3	.4	61.9	4.8	3.2	1610	80.5	1.1	.1	6.1	.6	.4	160
	Max.,	15	17.4	1.8	81.5	13.0	14.6	1820	90.6	3.2	.2	14.3	1.3	1.5	355
	Avg.,	15	**11.6**	**.8**	**74.8**	**6.4**	**6.4**	**1760**	**85.6**	**1.7**	**.1**	**10.8**	**.9**	**.9**	**255**
Carrots,	Min.,	4	8.0	1.7	67.2	7.6	4.9	1700	87.5	.8	.2	6.7	.8	.6	170
	Max.,	4	9.6	3.9	74.0	10.8	11.2	1860	90.1	1.2	.5	9.3	1.1	1.1	235
	Avg.,	4	**8.9**	**2.3**	**71.3**	**9.2**	**8.3**	**1760**	**89.3**	**1.0**	**.3**	**7.6**	**1.0**	**.8**	**190**
Mangolds,	Min.,	8	7.8	.7	46.8	6.2	7.8	1550	86.9	1.0	.1	2.7	.6	1.0	85
	Max.,	8	26.4	2.6	73.4	10.6	19.1	1730	94.3	1.9	.2	9.6	1.3	1.4	225
	Avg.,	8	**14.8**	**1.3**	**63.5**	**8.5**	**11.9**	**1670**	**90.2**	**1.3**	**.1**	**6.5**	**.8**	**1.1**	**165**

Pumpkin,	Min.,	6	11.5	1.3	19.6	14.6	6.1	1705	75.9	.9	.1	3.1	.9	.6	95
	Max.,	6	26.3	30.2	63.3	25.2	11.6	2460	94.4	6.3	7.1	6.8	4.1	1.7	580
	Avg.,	6	**19.6**	**11.8**	**40.5**	**19.1**	**9.0**	**1970**	**85.5**	**3.2**	**2.5**	**4.8**	**2.8**	**1.2**	**305**
Potatoes,	Min.,	7	9.6	.3	78.8	1.9	3.4	1755	75.4	1.8	.1	14.1	.4	.8	360
	Max.,	7	13.5	.8	82.9	3.5	6.4	1810	82.2	3.0	.2	20.4	.7	1.2	445
	Avg.,	7	**10.8**	**.5**	**81.0**	**2.7**	**5.0**	**1780**	**79.1**	**2.3**	**.1**	**16.9**	**.6**	**1.0**	**370**
Ruta-bagas,	Min.,	4	8.1	1.2	62.3	9.1	6.6	1665	87.2	.9	.1	5.1	1.0	.7	140
	Max.,	4	11.5	4.9	71.3	13.1	11.9	1725	91.8	1.3	.5	8.8	1.4	1.1	220
	Avg.,	4	**10.3**	**2.4**	**67.0**	**11.2**	**9.1**	**1745**	**89.1**	**1.1**	**.3**	**7.3**	**1.2**	**1.0**	**190**
Squash,	Min.,	9	4.5	.4	28.8	6.8	4.9	1790	66.7	.7	.0	6.2	1.0	.5	190
	Max.,	9	23.9	28.1	81.5	19.9	10.4	2410	89.7	6.1	7.8	12.4	6.2	1.7	770
	Avg.,	9	**15.1**	**9.9**	**54.6**	**14.2**	**6.2**	**1980**	**81.4**	**3.0**	**2.4**	**9.3**	**2.8**	**1.1**	**380**
Turnips,	Min.,	4	9.7	1.4	64.8	10.1	7.9	1730	87.2	.8	.1	1.4	.8	.7	140
	Max.,	4	11.3	4.1	70.6	12.6	9.5	1745	91.8	1.4	.4	6.3	8.8	1.0	225
	Avg.,	4	**10.5**	**2.3**	**67.5**	**11.0**	**8.7**	**1750**	**90.3**	**1.0**	**.2**	**4.7**	**2.9**	**.9**	**170**
*Milling and By-Products.**															
Corn meal,	Min.,	77	8.1	2.5	73.2	.6	1.0	1880	8.0	7.1	2.0	60.4	.5	.9	1405
	Max.,	77	16.8	5.8	84.8	3.6	5.0	1965	27.4	13.9	5.1	74.0	3.1	4.1	1805
	Avg.,	77	**10.8**	**4.4**	**81.0**	**2.2**	**1.6**	**1935**	**15.0**	**9.2**	**3.8**	**68.7**	**1.9**	**1.4**	**1645**
Pea meal,	Min.,	2	21.0	1.0	55.0	12.6	2.9	1690	8.9	19.1	.9	50.2	11.1	2.6	1535
	Max.,	2	24.3	1.7	59.1	19.4	3.0	1985	12.1	21.4	1.5	52.0	17.7	2.7	1760
	Avg.,	2	**22.5**	**1.4**	**57.2**	**16.0**	**2.9**	**1840**	**10.5**	**20.2**	**1.2**	**51.1**	**14.4**	**2.6**	**1645**
Hominy chops,	Min.,	12	8.9	4.9	69.4	2.9	2.1	1935	8.1	7.9	4.5	61.0	2.5	1.9	1730
	Max.,	12	12.3	12.2	78.0	7.4	3.4	2090	13.5	11.2	11.2	71.1	6.7	3.1	1915
	Avg.,	12	**11.0**	**9.3**	**72.6**	**4.3**	**2.8**	**2030**	**11.0**	**9.8**	**8.3**	**64.6**	**3.8**	**2.5**	**1805**
Corn (maize) germ,	Min.,	3	10.8	6.0	68.6	2.2	2.1	1860	9.4	9.7	5.2	61.9	1.9	1.9	1690
	Max.,	3	11.2	12.2	77.5	6.3	8.2	2110	13.0	9.9	11.2	67.4	5.8	7.4	1915
	Avg.,	3	**11.0**	**8.2**	**71.7**	**4.6**	**4.5**	**1970**	**10.7**	**9.8**	**7.4**	**64.0**	**4.1**	**4.0**	**1760**
Gluten meal,	Min.,	32	22.7	3.8	32.9	.3	.1	1930	6.4	21.3	3.4	44.7	.3	.1	1715
	Max.,	32	39.3	10.6	66.3	5.4	1.4	2090	12.3	35.5	9.6	58.5	5.0	1.7	1935
	Avg.,	32	**32.5**	**7.0**	**57.9**	**1.8**	**.8**	**2010**	**9.6**	**29.4**	**6.3**	**52.4**	**1.6**	**.7**	**1817**

* From compilation of Analyses of American Feeding Stuffs, by Jenkins & Winton, *loc. cit.*

TABLE 48.—(*Continued.*)

Kind.		No. of Analysis.	In Water-free Substance.						Calculated to Water Content at Time of Sampling.						
			Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.	Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Calories per Pound.
			%	%	%	%	%		%	%	%	%	%	%	
Milling and By-Products. (*Continued.*)															
Buffalo gluten feed,*	Min.,	6	13.0	10.5	53.0	5.8	.8	2090	7.8	11.8	9.6	48.8	5.3	.7	1930
	Max.,	6	26.5	15.4	63.9	8.5	1.4	2200	9.6	24.2	13.9	57.7	7.9	1.3	1985
	Avg.,	6	**22.4**	**12.5**	**56.9**	**7.2**	**1.0**	**2135**	**8.6**	**20.5**	**11.4**	**52.0**	**6.6**	**.9**	**1955**
Chicago gluten meal,*	Min.,	3	27.9	5.2	49.8	1.7	.9	1965	7.2	25.9	4.7	45.1	1.6	.8	1785
	Max.,	3	42.4	12.6	53.7	5.6	1.3	2135	9.1	38.6	11.7	49.8	5.2	1.2	1985
	Avg.,	3	**32.8**	**10.1**	**52.1**	**3.9**	**1.1**	**2075**	**7.8**	**30.2**	**9.3**	**48.0**	**3.7**	**1.0**	**1915**
Cream gluten.*	Min.,	3	37.0	14.7	38.4	1.3	.7	2195	7.7	34.1	13.6	35.0	1.2	.6	2025
	Max.,	3	42.0	17.3	44.5	1.4	.9	2250	9.0	38.2	15.8	41.1	1.3	.8	2055
	Avg.,	3	**39.3**	**16.1**	**42.4**	**1.4**	**.8**	**2225**	**8.1**	**36.1**	**14.8**	**39.0**	**1.3**	**.7**	**2045**
Starch feed, wet,	Min.,	12	12.5	3.5	51.1	4.2	.4	1930	62.3	3.6	1.3	18.7	1.6	.1	560
	Max.,	12	22.4	12.6	68.5	14.7	2.0	2130	72.2	9.6	4.4	28.9	4.4	.6	895
	Avg.,	12	**17.6**	**9.1**	**63.6**	**8.9**	**.8**	**2060**	**65.4**	**6.1**	**3.1**	**22.0**	**3.1**	**.3**	**710**
Oat feed,	Min.,	4	13.8	6.8	61.2	4.0	3.4	1935	6.4	12.6	6.1	56.2	3.7	3.2	1770
	Max.,	4	22.0	8.4	68.0	13.6	4.6	1995	9.2	20.0	7.8	63.7	12.5	4.2	1865
	Avg.,	4	**17.3**	**7.7**	**64.4**	**6.6**	**4.0**	**1965**	**7.7**	**16.0**	**7.1**	**59.4**	**6.1**	**3.7**	**1815**
Malt sprouts,	Min.,	4	23.7	1.1	51.6	10.5	4.3	1745	7.3	21.0	1.1	45.5	9.3	3.8	1545
	Max.,	4	29.3	3.2	56.7	13.6	7.5	1805	12.0	25.9	3.0	50.3	12.0	6.7	1675
	Avg.,	4	**25.8**	**1.9**	**54.2**	**11.8**	**6.3**	**1790**	**10.2**	**23.2**	**1.7**	**48.5**	**10.7**	**5.7**	**1605**

Brewers' grains, wet,	Min.,	15	18.9	3.6	41.5	10.9	1.2	1830	68.6	4.3	.8	9.6	3.1	.3	400
	Max.,	15	26.6	9.3	56.7	22.5	6.3	1990	79.4	6.9	2.9	15.9	5.6	1.5	620
	Avg.,	15	**22.4**	**6.5**	**51.5**	**15.7**	**3.9**	**1940**	**75.7**	**5.4**	**1.6**	**12.5**	**3.8**	**1.0**	**470**
Brewers' grains, dried,	Min.,	3	20.5	4.4	52.3	10.9	3.5	1900	6.2	19.3	4.2	46.1	10.2	3.3	1725
	Max.,	3	23.0	7.4	60.7	13.2	4.3	1955	11.9	20.3	6.5	56.8	11.6	3.8	1810
	Avg.,	3	**21.7**	**6.1**	**56.3**	**12.0**	**3.9**	**1930**	**8.2**	**19.9**	**5.6**	**51.7**	**11.0**	**3.6**	**1770**
Rye bran,	Min.,	7	13.2	2.1	68.6	2.9	3.3	1810	8.2	11.5	1.8	59.8	2.5	2.9	1570
	Max.,	7	19.0	5.6	76.9	4.7	5.2	1915	13.7	16.8	4.9	67.6	4.1	4.5	1675
	Avg.,	7	**16.6**	**3.2**	**72.1**	**4.0**	**4.1**	**1860**	**11.6**	**14.7**	**2.8**	**63.8**	**3.5**	**3.6**	**1645**
Wheat bran,	Min.,	88	13.7	1.8	52.1	2.7	2.9	1785	7.4	12.1	1.5	45.5	2.4	2.5	1500
	Max.,	88	20.6	7.8	72.4	17.7	8.4	1900	15.8	18.9	7.0	63.2	15.5	7.3	1735
	Avg.,	88	**17.4**	**4.5**	**61.3**	**10.2**	**6.6**	**1845**	**11.9**	**15.4**	**4.0**	**53.9**	**9.0**	**5.8**	**1625**
Wheat middlings,	Min.,	32	11.7	2.3	60.6	1.4	1.6	1850	9.2	10.1	2.1	53.0	1.3	1.4	1620
	Max.,	32	22.8	6.5	79.9	13.9	7.5	1915	16.0	20.0	5.9	70.9	12.7	6.3	1820
	Avg.,	32	**17.8**	**4.5**	**68.7**	**5.2**	**3.8**	**1895**	**12.1**	**15.6**	**4.0**	**60.4**	**4.6**	**3.3**	**1675**
Buckwheat middlings,	Min.,	3	27.8	6.3	42.9	2.7	5.0	1915	9.5	25.1	5.7	36.3	2.4	4.4	1635
	Max.,	3	36.2	9.2	58.2	6.6	6.6	1980	16.3	31.3	8.1	52.7	5.7	5.5	1735
	Avg.,	3	**33.3**	**8.1**	**48.5**	**4.6**	**5.5**	**1950**	**13.2**	**28.9**	**7.1**	**42.0**	**4.0**	**4.8**	**1690**
Cotton seed meal,	Min.,	35	25.0	9.7	13.7	1.4	6.1	1940	5.8	23.3	8.8	15.7	1.3	5.7	1685
	Max.,	35	53.9	19.4	41.7	12.6	9.6	2200	18.5	50.8	18.0	38.7	10.1	8.8	2040
	Avg.,	35	**46.1**	**14.2**	**25.8**	**6.1**	**7.8**	**2050**	**8.2**	**42.3**	**13.1**	**23.6**	**5.6**	**7.2**	**1880**
Linseed meal, old process,	Min.,	21	29.5	5.6	33.5	5.2	4.0	1835	5.6	27.7	5.1	28.4	4.7	4.6	1635
	Max.,	21	41.3	12.7	44.8	14.3	8.4	2040	12.4	38.2	11.6	41.9	13.3	8.2	1910
	Avg.,	21	**36.2**	**8.6**	**39.2**	**9.7**	**6.3**	**1945**	**9.2**	**32.9**	**7.9**	**35.4**	**8.9**	**5.7**	**1770**
Linseed meal, new process,	Min.,	14	29.0	1.5	39.5	8.3	5.5	1765	6.1	27.1	1.3	35.2	7.6	5.0	1530
	Max.,	14	40.9	4.7	51.7	15.2	7.5	1865	13.4	38.4	4.4	48.0	14.0	6.9	1720
	Avg.,	14	**36.9**	**3.3**	**42.8**	**10.5**	**6.5**	**1820**	**10.1**	**33.2**	**3.0**	**38.4**	**9.5**	**5.8**	**1635**

* In the earlier analyses of gluten meal little account was made of its source. The few analyses of Buffalo, Chicago and cream gluten given here were made by the Connecticut and the Storrs Stations during 1892–93.

THE DIGESTIBILITY OF FEEDING STUFFS.

BY CHAS. D. WOODS.

It is a matter of every-day experience that only a part of the food eaten is actually used by the animal. It is, therefore, of importance in cattle feeding to have a knowledge, not only of the chemical composition of a given food, but of the amounts of the nutrients, which are capable of being assimilated. It is not so much what an animal eats, as that which it digests, that is actually turned to account.

The word digestibility as commonly used has more than one meaning. People often speak of one food as being more digestible than another, when they mean it is more quickly or easily digested. As here used, the term digestibility means the proportion of any given food or food constituent which is digested under usual conditions, without regard to the time needed or the ease of digestion.

DIGESTION EXPERIMENTS—HOW CONDUCTED.

A digestion experiment is managed as follows: Selected animals are fed with the kind of food to be tested, the chemical composition of which has been ascertained by careful analysis. A weighed portion is fed, care being taken to see that none is wasted, and that all the uneaten residues are weighed and analyzed. In this way the exact weights of protein, fat, fiber, nitrogen-free extract and ash eaten are ascertained. The solid excrement of the animal contains the undigested residues. This is carefully collected, dried, weighed, and analyzed, and the amounts of undigested protein, fat, fiber, nitrogen-free extract and ash contained in it are found. The difference between the amounts found in the undigested residues and the amounts contained in the food eaten is taken as a measure of the amounts of the various nutrients which have been digested and assimilated by the animals.

While this experiment seems comparatively simple, it is surrounded by difficulties which render the work laborious and tend to make the results somewhat uncertain.

Many analyses have been made of nearly all of the materials commonly used for food for cattle, and in consequence we have a fairly good knowledge of their composition. A good many experiments upon the digestibility of the different food materials have been made, but these are necessarily much less in number, and also less accurate in their carrying out than are mere analyses. Considering the short time that the experiment stations have been established in this country, quite a large number of digestion experiments upon American feeding stuffs have been made, but by far the larger number of experiments have been made in Europe, and especially in Germany. Just as it has been of great practical importance to make large numbers of analyses of American foods in order that we may know the composition of American feeding stuffs, so it is important to have a large number of accurately conducted digestion experiments upon American feeding materials. The results already obtained are in many instances more valuable for our conditions than are the results of the much larger number of German experiments.

The tables (Nos. 49 and 50) which follow give a summary of the results of digestion experiments up to the years 1891–2. Table 49 is a translation of the summation table prepared by Profs. Dietrich and König,* and it contains the results of all published European digestion experiments obtainable by these very careful and painstaking compilers. A few American studies are also included.

Table 50 contains a tentative summary of the results of American digestion experiments prepared by Professor W. H. Jordan, Director of the Maine Experiment Station, for the Office of Experiment Stations of the U. S. Department of Agriculture. It is here printed by the courteous consent of the Office of Experiment Stations.

The tables require little explanation. In table 49 there are given the minima and maxima figures as well as the averages obtained in the experiments. The first column in each table gives the number of animals experimented with, and the second column the total number of tests of digestibility of the given feeding stuff made with these animals. In the original of table 49 the results are given to the second decimal place, but they are here given to the nearest whole per cent. in each case.

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* *Zusammensetzung und Verdaulichkeit der Futtermittel.*

TABLE 49.

*Maximum, Minimum and Average Coefficients of Digestibility of European Feeding Stuffs.**

Reference No.	KIND OF FEEDING STUFF.		No. of Experiments.	No. of Trials.	Organic Matter.	Protein.	Fat.	Nit.-free Substance.	Fiber.
	EXPERIMENTS WITH RUMINANTS.				%	%	%	%	%
	Green Fodders, Ensilage and Hay.								
1	Pasture grass (cut before May 15),	Min.,	2	4	75	71	63	75	70
		Max.,	2	4	79	79	68	84	75
		Avg.,	2	4	77	75	66	79	73
2	Meadow grass in June,	Avg.,	1	2	71	70	62	75	66
3	Mixed fodder (clover and grass), green,	Avg.,	1	2	75	78	64	78	67
4	Mixed fodder (clover and grass), hay,	Avg.,	1	2	63	61	63	71	49
5	Fodder rye, young, green,	Avg.,	1	2	—	79	74	71	80
6	Green sorghum,	Avg.,	1	1	73	62	85	78	60
7	Green maize, cut early,	Avg.,	1	1	70	73	75	67	72
8	Maize ensilage,	Min.,	3	3	61	45	82	66	47
		Max.,	3	3	63	54	86	72	64
		Avg.,	3	3	62	48	85	68	56
9	Maize fodder, cured,	Min.,	3	3	62	44	52	64	56
		Max.,	3	3	68	52	79	68	71
		Avg.,	3	3	63	48	67	66	64
10	Red beet tops ensilage,	Avg.,	1	2	57	65	60	54	54
11	Potato tops (beginning of October),	Avg.,	1	2	48	42	24	60	36
12	Poplar leaves (beginning of October),	Avg.,	1	2	58	56	79	65	35
13	Butter cups *(Ranunculus acris)*,	Avg.,	1	1	57	8	69	67	41
14	Daisy, white weed *(Lucanthemum vulgare)*,	Avg.,	1	1	58	58	62	67	46
15	Comfrey *(Symphytum asperrimum)* hay,	Avg.,	1	2	69	58	71	85	18
16	Timothy hay in bloom,	Min.,	4	5	50	45	35	58	39
		Max.,	4	5	67	60	56	72	62
		Avg.,	4	5	57	49	49	63	50
17	Orchard grass hay, after blooming,	Avg.,	1	1	56	59	51	54	51
18	Red-top in bloom,	Avg.,	1	1	59	60	44	59	61
19	Blue joint, end of July,	Avg.,	1	1	42	56	37	43	37
20	Barnyard grass, in milk, hay,	Avg.,	1	1	63	62	60	66	63
21	Wild oat grass *(Danthonia spicata)* in bloom, hay,	Avg.,	1	1	61	49	38	62	65
22	*Imperata arundinacea*, hay,	Avg.,	1	2	49	52	38	42	56
23	Couch grass *(Triticum ripens)* in bloom,	Avg.,	1	1	61	64	60	62	59
24	Hay from uncultivated lands in Japan,	Avg.,	1	2	53	41	43	44	65
25	Hay from uncultivated lands in Japan, with more legumes,	Avg.,	1	2	49	24	41	41	63
26	Hay from mixed grasses, best quality,	Min.,	18	48	61	60	45	58	53
		Max.,	18	48	79	73	68	76	80
		Avg.,	18	48	67	65	57	68	63

* Taken from *Zusammensetzung und Verdaulichkeit der Futtermittel* by Dr. Th. Dietrich and Dr. J. König, Berlin, 1891.

TABLE 49.—*(Continued.)*

Reference No.	Kind of Feeding Stuff.		No. of Experiments.	No. of Trials.	Organic Matter.	Protein.	Fat.	Nit.-free Substance.	Fiber.
	EXPERIMENTS WITH RUMINANTS. *Green Fodder, Ensilage and Hay.—(Cont'd.)*				%	%	%	%	%
27	Hay from mixed grasses, medium quality,	Min.,	35	94	50	49	15	53	51
		Max.,	35	94	67	67	70	73	71
		Avg.,	35	94	**61**	**57**	**53**	**64**	**60**
28	Hay from mixed grasses, poor quality,	Min.,	10	28	46	35	10	49	46
		Max.,	10	28	59	60	57	65	64
		Avg.,	10	28	**56**	**50**	**49**	**59**	**56**
29	Rowen hay,	Min.,	6	30	60	54	28	63	61
		Max.,	6	30	71	68	56	74	68
		Avg.,	6	30	**64**	**62**	**46**	**67**	**64**
30	Red clover, green, before bloom,	Avg.,	1	2	**74**	**74**	**65**	**83**	**60**
31	Red clover, green, beginning to bloom,	Min.,	2	4	67	72	66	73	52
		Max.,	2	4	72	76	75	82	60
		Avg.,	2	4	**71**	**74**	**71**	**79**	**57**
32	Red clover, green, full bloom and past,	Min.,	2	4	58	56	42	70	38
		Max.,	2	4	65	70	64	73	49
		Avg.,	2	4	**61**	**64**	**53**	**71**	**44**
33	Red clover hay, best quality,	Min.,	7	17	59	59	54	63	45
		Max.,	7	17	67	71	74	76	54
		Avg.,	7	17	**63**	**66**	**65**	**70**	**50**
34	Red clover, hay, medium quality,	Min.,	10	21	52	48	33	57	38
		Max.,	10	21	57	59	63	69	52
		Avg.,	10	21	**56**	**54**	**53**	**64**	**46**
35	Alfalfa, in bloom, green,	Min.,	3	6	57	78	37	65	32
		Max.,	3	6	68	83	54	77	47
		Avg.,	3	6	**64**	**81**	**45**	**72**	**41**
36	Alfalfa, carefully dried,	Min.,	3	6	57	70	30	65	34
		Max.,	3	6	62	83	51	71	46
		Avg.,	3	6	**62**	**80**	**41**	**69**	**41**
37	Alfalfa hay, early bloom, best quality,	Min.,	8	26	54	71	26	53	34
		Max.,	8	26	67	83	58	72	49
		Avg.,	8	26	**61**	**76**	**46**	**68**	**42**
38	Alfalfa hay, full bloom, medium quality,	Min.,	4	10	55	66	49	61	39
		Max.,	4	10	59	73	56	65	48
		Avg.,	4	10	**57**	**68**	**53**	**63**	**45**
39	Alfalfa, carefully dried,*	Avg.,	1	2	**57**	**78**	**50**	**65**	**35**
40	Alfalfa hay,*	Avg.,	1	2	**55**	**73**	**32**	**65**	**37**
41	Alfalfa hay, overdried *(Brennheu)*,*	Avg.,	1	2	**54**	**72**	**43**	**54**	**45**
42	Alsike clover, in full bloom,	Min.,	2	4	56	49	35	63	44
		Max.,	2	4	63	64	55	74	51
		Avg.,	2	4	**59**	**61**	**44**	**69**	**51**
43	White clover hay,	Avg.,	1	1	**67**	**73**	**51**	**70**	**51**
44	Sanfoin, early bloom, green,	Avg.,	1	2	**66**	**73**	**67**	**78**	**42**
45	Sanfoin hay, carefully dried,	Avg.,	1	2	**62**	**70**	**67**	**74**	**36**
46	Sanfoin hay, overdried *(Brennheu)*,	Avg.,	1	2	**59**	**64**	**76**	**67**	**45**
47	Sanfoin ensilage,	Avg.,	1	2	**45**	**50**	**74**	**53**	**29**

* Nos. 39, 40 and 41 are results of experiments upon different portions of the same alfalfa differently cured.

TABLE 49.—(*Continued.*)

Reference No.	Kind of Feeding Stuff.		No. of Experiments.	No. of Trials.	Organic Matter.	Protein.	Fat.	Nit.-free Substance.	Fiber.
	EXPERIMENTS WITH RUMINANTS.				%	%	%	%	%
	Green Fodder Ensilage and Hay.—(Cont'd.)								
48	Serradella, in bloom, hay,	Avg.,	1	2	62	75	65	63	50
49	Serradella, in seed, hay,	Avg.,	1	2	47	63	66	48	37
50	Vetch, before bloom, hay,	Avg.,	1	6	65	76	60	66	54
51	Lupin, hay,	Avg.,	1	2	—	74	30	62	73
52	Soy bean, hay,	Min.,	2	4	58	63	14	59	46
		Max.,	2	4	63	76	48	71	58
		Avg.,	2	4	61	69	30	66	53
	Straw, etc.								
53	Wheat straw,	Min.,	2	3	45	18	27	36	52
		Max.,	2	3	48	26	58	40	59
		Avg.,	2	3	46	23	36	39	56
54	Rye straw,	Min.,	3	9	40	21	21	29	47
		Max.,	3	9	51	29	41	52	73
		Avg.,	3	9	48	25	29	39	63
55	Oat straw,	Min.,	5	9	49	25	14	33	50
		Max.,	5	9	53	50	51	55	66
		Avg.,	5	9	51	40	32	47	58
56	Barley straw,	Min.,	2	5	50	22	38	49	54
		Max.,	2	5	56	26	43	59	58
		Avg.,	2	5	53	25	42	54	56
57	Maize stover,	Avg.,	1	1	—	37	28	40	52
58	Rice straw,	Min.,	2	4	43	41	37	27	55
		Max.,	2	4	53	47	52	38	61
		Avg.,	2	4	47	45	47	32	57
59	Bean straw,	Min.,	3	5	51	45	49	64	36
		Max.,	3	5	63	54	60	73	53
		Avg.,	3	5	55	49	57	68	43
60	Pea straw,	Avg.,	1	2	59	61	46	64	52
61	Lupin straw,	Avg.,	1	2	—	38	30	65	51
62	Soy bean straw,	Min.,	2	4	52	37	58	62	32
		Max.,	2	4	59	62	64	71	43
		Avg.,	2	4	55	50	60	66	38
63	Soy bean pods,	Avg.,	1	2	63	44	57	73	51
64	Extracted hops,	Min.,	2	4	29	24	49	43	10
		Max.,	2	4	41	39	77	53	26
		Avg.,	2	4	37	31	64	48	17
	Roots and Tubers.								
65	Potatoes,	Min.,	4	24	73	44	—	83	—
		Max.,	4	24	97	88	—	99	—
		Avg.,	4	24	86	61	—	90	—
66	Red beet,	Min.,	3	18	80	52	—	92	—
		Max.,	3	18	96	90	—	100	—
		Avg.,	3	18	88	77	—	96	—

TABLE 49.—*(Continued.)*

Reference No.	Kind of Feeding Stuff.		No. of Experiments.	No. of Trials.	Organic Matter.	Protein.	Fat.	Nit.-free Substance.	Fiber.
	EXPERIMENTS WITH RUMINANTS.				%	%	%	%	%
	Roots and Tubers.—(Cont'd.)								
		Min.,	2	28	81	34	—	90	—
67	Sugar beet,	Max.,	2	28	100	100	—	100	—
		Avg.,	2	28	88	62	—	95	—
68	Turnips,	Avg.,	1	8	78	57	—	88	—
69	Swedish turnip,	Avg.,	1	2	96	62	93	99	100
	Grain, Seeds and Fruits.								
		Min.,	11	39	62	68	68	65	2
70	Oats,	Max.,	11	39	82	94	100	94	47
		Avg.,	11	39	71	78	84	77	26
		Min.,	2	4	81	63	78	87	—
71	Barley,	Max.,	2	4	91	77	100	96	—
		Avg.,	2	4	86	70	89	92	—
		Min.,	4	12	88	64	73	90	46
72	Maize (Indian corn),	Max.,	4	12	93	84	99	99	100
		Avg.,	4	12	91	76	86	93	58
73	Dari,	Avg.,	1	2	86	65	70	91	51
		Min.,	8	29	76	77	56	82	25
74	Field beans,	Max.,	8	29	100	100	100	100	99
		Avg.,	8	29	89	88	82	92	72
75	Peas,	Avg.,	1	2	90	89	75	93	66
		Min.,	6	12	81	85	71	75	77
76	Lupin,	Max.,	6	12	99	96	96	100	100
		Avg.,	6	12	89	90	82	83	91
77	Lupin, steamed and not extracted,	Avg.,	1	2	92	92	90	89	—
78	Lupin, steamed and extracted,	Avg.,	1	2	97	94	94	84	—
79	Lupin, in natural condition,	Avg.,	1	2	81	87	71	76	77
80	Lupin, strongly steamed,	Avg.,	1	2	68	67	84	66	69
81	Vetch,	Avg.,	1	2	92	88	92	100	—
82	Soy beans,	Avg.,	1	2	85	87	94	62	—
		Min.,	2	7	68	81	78	39	1
83	Linseed,	Max.,	2	7	91	100	90	81	100
		Avg.,	2	7	77	91	86	55	60
84	Horse chestnuts,	Avg.,	1	1	100	60	85	93	—
85	Acorns,	Avg.,	1	2	88	83	88	91	62
86	Carot bean *(Johannisbrod)*,	Avg.,	1	2	94	68	54	95	—
	By-products or Wastes.								
		Min.,	6	48	63	51	50	70	—
87	Wheat bran,	Max.,	6	48	85	100	90	88	58
		Avg.,	6	48	71	78	72	76	30
88	Spelt *(Triticum spelta)* bran,	Avg.,	2	3	90	73	88	91	59
89	Rye bran,	Avg.,	1	4	—	41	—	61	—
90	Gluten meal from wheat,	Avg.,	1	2	91	88	46	92	100
91	Gluten meal from maize (corn),	Avg.,	1	1	—	85	76	94	34
92	Rice (fodder) meal,	Avg.,	1	2	89	77	89	100	67
93	Rice (fodder), poor quality,	Avg.,	1	2	66	45	83	84	34

TABLE 49.—*(Continued.)*

Reference No.	Kind of Feeding Stuff.		No. of Experiments.	No. of Trials.	Organic Matter.	Protein.	Fat.	Nit.-free Substance.	Fiber.
	EXPERIMENTS WITH RUMINANTS.				%	%	%	%	%
	By-Products or Wastes.—(Cont'd.)								
94	Malt sprouts, - - - - -	Min.,	4	9	64	73	43	58	32
		Max.,	4	9	82	100	100	94	95
		Avg.,	4	9	**75**	**81**	**68**	**76**	**64**
95	Brewers' grains, fresh, - - -	Avg.,	1	2	**63**	**73**	**84**	**64**	**39**
96	Brewers' grains, dried, - - -	Min.,	2	7	54	62	66	51	21
		Max.,	2	7	72	73	87	74	64
		Avg.,	2	7	**62**	**69**	**81**	**63**	**39**
97	Beet diffusion residue, dried, - -	Avg.,	2	6	—	**63**	—	**85**	**84**
98	Linseed oil meal, linseed cake, -	Min.,	2	10	74	80	87	60	23
		Max.,	2	10	88	90	94	96	93
		Avg.,	2	10	**81**	**86**	**90**	**80**	**50**
99	Linseed oil meal, without fat, - -	Avg.,	1	8	**71**	**82**	**91**	**73**	—
100	Rape seed oil cake, - - -	Min.,	2	7	48	65	60	66	—
		Max.,	2	7	79	92	94	85	34
		Avg.,	2	7	**79**	**81**	**79**	**76**	**8**
101	Rape seed oil meal, without fat, -	Avg.,	1	1	**68**	**84**	—	**85**	—
102	Peanut oil cake, - - - - -	Avg.,	2	4	**85**	**90**	**86**	**93**	**16**
103	Cocoanut oil cake, - - - -	Avg.,	1	2	**78**	**76**	**100**	**77**	**62**
104	Cotton seed oil cake, with hulls, -	Min.,	2	8	50	72	86	46	2
		Max.,	2	8	60	77	93	60	24
		Avg.,	2	8	**54**	**74**	**90**	**51**	**16**
105	Cotton seed oil cake, without hulls, -	Min.,	2	4	80	84	85	66	—
		Max.,	2	4	81	89	100	84	—
		Avg.,	2	4	**81**	**87**	**95**	**76**	—
106	Sesame *(Sesam indicum)* oil cake, -	Avg.,	1	4	**77**	**90**	**90**	**57**	**31**
107	Palm nut oil cake, - - - -	Avg.,	1	2	**75**	**77**	**94**	**79**	**54**
108	Palm nut oil meal (fat removed), -	Min.,	2	3	89	87	88	92	72
		Max.,	2	3	96	100	100	99	95
		Avg.,	2	3	**91**	**95**	**95**	**94**	**82**
109	Sunflower seed oil cake, - - -	Avg.,	1	4	**76**	**90**	**88**	**71**	**31**
	Animal Foods.								
110	Cows' milk, - - - - -	Min.,	5	5	97	91	100	93	—
		Max.,	5	5	99	97	100	99	—
		Avg.,	5	5	**98**	**94**	**100**	**98**	—
111	Flesh meal (ground meat), - -	Min.,	2	3	92	94	96	—	—
		Max.,	2	3	96	97	100	—	—
		Avg.,	2	3	**93**	**96**	**99**	—	—
112	Blood meal, - - - - - -	Avg.,	1	2	**63**	**62**	**100**	100	—
113	Fish meal, - - - - - -	Avg.,	1	2	—	**90**	**76**	—	—
	EXPERIMENTS WITH HORSES.								
114	Best mixed hay, - - - - -	Min.,	3	4	54	59	10	60	42
		Max.,	3	4	62	69	43	69	57
		Avg.,	3	4	**58**	**64**	**22**	**66**	**48**
115	Medium mixed hay, - - -	Min.,	11	14	40	46	7	49	21
		Max.,	11	14	60	66	43	63	48
		Avg.,	11	14	**50**	**59**	**18**	**58**	**39**

TABLE 49.—*(Continued.)*

Reference No.	Kind of Feeding Stuff.		No. of Experiments.	No. of Trials.	Organic Matter.	Protein.	Fat.	Nit.-free Substance.	Fiber.
					%	%	%	%	%
	EXPERIMENTS WITH HORSES.—*(Cont'd.)*								
		Min.,	4	12	42	43	6	45	34
116	Poor mixed hay,	Max.,	4	12	51	62	33	61	49
		Avg.,	4	12	46	55	24	52	38
		Min.,	4	5	49	51	27	61	35
117	Red clover hay,	Max.,	4	5	55	60	31	67	41
		Avg.,	4	5	51	56	29	64	37
		Min.,	4	6	55	70	6	67	33
118	Alfalfa,	Max.,	4	6	62	77	30	71	44
		Avg.,	4	6	58	73	14	70	40
		Min.,	3	6	1	12	—	4	3
119	Wheat straw,	Max.,	3	6	56	44	—	56	54
		Avg.,	3	6	21	28	66	28	18
120	Spelt *(Triticum spelta)* straw,	Avg.,	1	1	25	23	20	18	30
121	Potatoes,	Avg.,	1	1	93	88	—	99	9
122	Carrots,	Avg.,	1	1	87	99	—	94	—
		Min.,	16	34	61	68	50	70	1
123	Oats,	Max.,	16	34	80	94	88	84	56
		Avg.,	16	34	69	80	71	75	29
124	Barley,	Avg.,	1	1	87	80	42	87	100
		Min.,	2	2	87	75	59	90	41
125	Maize (corn),	Max.,	2	2	91	78	63	94	100
		Avg.,	2	2	89	76	61	92	41
126	Field beans,	Avg.,	1	5	87	86	13	94	65
127	Peas,	Avg.,	1	1	80	83	7	89	8
128	Lupin (extracted),	Avg.,	1	1	72	94	27	51	51
	EXPERIMENTS WITH SWINE.								
		Min.,	5	9	91	57	—	97	28
129	Potatoes,	Max..	5	9	96	88	—	99	83
		Avg.,	5	9	93	72	—	98	55
		Min.,	6	13	78	67	51	87	14
130	Barley (hulled),	Max.,	6	13	85	81	77	91	29
		Avg.,	6	13	82	75	65	90	15
		Min.,	3	4	90	84	74	93	17
131	Maize (corn), hulled,	Max.,	3	4	95	89	79	96	57
		Avg.,	3	4	92	86	76	95	40
132	Rice (hulled),	Avg.,	2	2	98	86	70	100	—
		Min.,			88	84	36	95	55
133	Peas (hulled),	Max.,			93	91	69	99	89
		Avg.,			91	88	49	97	68
134	Rye bran,	Avg.,	1	2	67	66	58	75	9
135	Cocoanut oil cake,	Avg.,	1	2	80	73	83	89	60
136	Flesh meal,	Avg.,	1	8	92	97	86	—	—
137	Blood meal,	Avg.,	1	1	72	72	—	92	—
138	May beetle *(Maikaefer)*,	Avg.,	1	6	57	69	83	—	—
139	Sour milk (loppered),	Avg.,	1	1	95	96	95	99	—

TABLE 50.

*Coefficients of Digestibility of American Feeding Stuffs as determined by American Experiments.**

Reference No.	KIND OF FEEDING STUFF.	No. of Experiments.	No. of Trials.	Dry Matter.	Organic Matter.	Protein (N. × 6.25).	Fat.	Nitrogen-free Extract.	Fiber.
	EXPERIMENTS WITH RUMINANTS.			%	%	%	%	%	%
1	Pasture grass, - - - - -	3	4	71	—	71	63	74	75
2	Soiling rye, - - - - -	1	2	74	—	79	74	71	80
3	Corn ensilage, - - - - -	10	18	64	—	46	80	67	67
4	Soiling clover, - - - - -	1	2	66	—	67	64	78	53
5	Sorghum, - - - -	1	2	61	—	40	67	71	43
6	Timothy hay (all experiments), -	11	27	58	—	49	55	63	53
7	Timothy hay (early cut), - -	3	5	61	62	57	56	64	59
8	Timothy hay (late cut), - -	3	6	53	54	45	58	60	46
9	Hungarian hay, - - -	1	6	64	66	61	58	66	68
10	Blue-joint hay, - - -	2	3	54	56	63	45	56	54
11	Orchard grass hay, - - -	2	3	56	—	59	54	55	60
12	Red-top hay, - - - -	2	3	59	61	61	50	62	61
13	Witch grass hay, - - -	2	3	61	62	59	57	65	63
14	Wild oat grass hay, - - -	2	2	64	65	58	50	65	68
15	Mixed hay (clover and timothy),	2	3	55	—	42	54	57	49
16	Clover hay (red), - - -	2	7	53	54	52	48	61	47
17	Alsike clover hay (cut in bloom),	1	3	62	63	66	50	71	53
18	White clover hay (in late bloom),	1	1	66	67	73	51	69	61
19	Alfalfa hay, - - - -	2	3	—	—	73	51	68	46
20	Corn fodder (whole plant), -	19	37	67	—	58	71	69	70
21	Corn stover, - - - - -	1	4	62	—	52	52	64	66
22	Oat straw, - - - - -	1	2	50	51	—	37	52	57
23	Potatoes, - - - - - -	1	3	77	78	44	13	91	—
24	Roots, - - - - - -	4	8	88	92	84	77	95	80
25	Corn meal, - - - - -	1	2	85	—	58	92	87	—
26	Pea meal, - - - - -	1	2	87	88	83	54	94	26
27	Malt sprouts, - - - -	1	1	67	67	80	—	68	33
28	Cotton seed meal, - - -	1	2	81	81	89	100	68	—
29	Wheat bran, - - - - -	2	4	59	63	78	73	66	—
30	Wheat middlings, - - -	1	2	75	77	79	85	83	—
31	Gluten meal, - - - -	1	2	87	89	87	88	91	—
32	Cotton seed hulls, - - -	1	1	36	—	25	81	40	27
	EXPERIMENTS WITH SWINE.								
33	Whole corn (kernel), - -	1	1	82	83	69	46	89	38
34	Corn meal, - - - - -	1	1	89	91	86	82	94	29
35	Corn and cob meal, - - -	1	1	76	77	76	82	84	28

* From a compilation made by Prof. W. H. Jordan, Director of the Maine Agricultural Experiment Station, for the Office of Experiment Stations of the U. S. Department of Agriculture, by whose courtesy this table is here printed.

An examination of table 49, in which there are given minima and maxima as well as average digestion coefficients, will show that in many instances there is a great range in the digestibility of the same kinds of feeding stuffs. This was to have been expected, since there are so many modifying elements entering into a digestion experiment. The kinds of animals used, their breeds, ages, and especially differences of individual animals, greatly modify the results. The methods of harvesting and curing, the period of growth at which the plant is cut, the length of time kept after curing, the quantities fed, whether fed green or cured, and the method of preparation of the food, all affect the digestibility of the feeding stuff and, moreover, mixtures of different feeds do not seem to be digested in the same way as the same feeds would be if fed alone. It follows from this, taken together with the comparatively small number of accurate digestion experiments thus far conducted, that it would not do to follow absolutely the figures of either tables 49 or 50.

Looking at tables 49 or 50, one will find that different species of grasses have in some instances very different digestibility. While it is probably true that there are specific differences in digestibility, it is very much to be doubted if the results of experiments thus far obtained would warrant us in assigning definite different coefficients of digestibility to different species of coarse fodders. In table 51, which follows, there is given a summary of the average coefficients of digestibility of tables 49 and 50. In this table (51), instead of arranging the coarse fodders under their specific names, materials which are more or less alike are classed together. Thus, under green fodders, the different kinds of grass, rye and allied plants are grouped together. The numbers in the table immediately following the words European and American refer to the reference numbers in the respective tables (49 and 50) from which the averages were obtained. It is of considerable interest to note that while individual experiments (see table 49) upon the same species have quite different range of digestibility, that the average of results obtained in the groups, in both European and American experiments, accord fairly well. There are also given in this table (51) the factors which were used in calculating the pounds of digestible matter in different feeding stuffs, as given in table 52. In the instances in which simply inspection of the table will not show how the factors used in table 52 were obtained, explanations are given in foot notes.

TABLE 51.

Average Coefficients of Digestibility of Different Classes of Feeding Stuffs as Ascertained by European and American Feeding Experiments, and the Factors Used in Computing Table 52.

KIND OF FEEDING STUFF.	No. of Tests.	Organic Matter.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.
GREEN FODDERS.						
Grass, Rye, Etc.		%	%	%	%	%
European (Nos. 1–3, 5 and 6), -	11	74	74	69	76	71
American (Nos. 1 and 2), - -	6	—	74	67	73	83
Factors used in table 52, - -	—	—	74	67	73	83
Corn Fodder.						
European (No. 1), - - -	1	70	73	75	67	72
Factors used in table 52,* -	—	—	74	67	73	83
Clover, Alfalfa, Etc.						
European (Nos. 30–32, 35 and 34),	18	66	74	57	75	47
American (No. 4), - - -	2	—	67	64	78	53
Factors used in table 52, - -	—	—	67	64	78	53
ENSILAGE.						
Corn Ensilage.						
European (No. 8), - - -	3	62	48	85	68	56
American (No. 3), - - -	18	—	46	80	67	67
Factors used in table 52, - -	—	—	46	80	67	67
DRY COARSE FODDERS.						
Hay of Grasses.						
European (Nos. 16–23, and 26–28),	183	61	58	53	63	60
American (Nos. 6 and 9–14), -	47	62	54	54	63	55
Factors used in table 52, - -	—	—	54	54	63	55
Corn Fodder.						
European (No. 9), - - -	3	63	48	67	66	64
American (No. 20), - - -	37	—	58	71	69	70
Factors used in table 52, - -	—	—	58	71	69	70
Corn Stalks (Stover).						
European (No. 57), - - -	1	—	37	28	40	52
American (No. 21), - - -	4	—	52	52	64	66
Factors used in table 52, - -	—	—	52	52	64	66
Mixed Hay, Clover and Timothy.						
American (No. 15), - - -	3	—	42	54	57	49
Factors used in table 52, - -	—	—	42	54	57	49
Rowen Hay.						
European (No. 29), - - -	30	64	62	46	67	64
Factors used in table 52, - -	—	—	62	46	67	64
Clover, Alfalfa, Etc., Hay.						
European (Nos. 33, 34, 36–43, 45, 46 and 48–50), - - -	109	57	68	52	66	46
American (Nos. 16, 17, 18 and 19),	14	57	61	49	65	46
Factors used in table 52, - -	—	—	61	49	65	46

* Same as for grass, rye, etc.

TABLE 51.—*(Continued.)*

KIND OF FEEDING STUFF.	No. of Tests.	Organic Matter.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.
Oat Straw.		%	%	%	%	%
European (No. 55), - - - -	26	51	40	32	47	58
American (No. 22), - - - -	2	51	—	37	52	57
Factors used in table 52, - -	—	—	40	37	52	57
TUBERS AND ROOTS.						
Potatoes.						
European (No. 65), - - - -	24	86	61	—	90	—
American (No. 23), - - - -	3	78	44	13	91	—
Factors used in table 52, - -	—	—	50	75*	91	33†
Roots.						
European (Nos. 68–69), - -	10	82	58	—	90	—
American (No. 24), - - - -	8	92	84	77	95	80
Factors used in table 52, - -	—	—	84	77	95	80
MILLING AND BY-PRODUCTS.						
Corn Meal.						
European (No. 72), - - - -	12	91	76	86	93	58
American (No. 25), - - - -	2	—	58	92	87	—
Factors used in table 52, - -	—	—	76†	92	87	58
Corn and Cob Meal.						
American, - - - - - -	1	77	76	82	84	28
Factors used in table 52, - -	—	—	76	82	84	28
Pea Meal.						
European (No. 75), - - - -	2	90	89	75	93	66
American (No. 26), - - - -	2	88	83	54	94	26
Factors used in table 52, - -	—	—	83	54	94	26
Gluten Meal from Corn.						
European (No. 91), - - - -	1	—	85	76	94	34
American, - - - - - -	2	89	87	88	91	—
Factors used in table 52, - -	—	—	87	88	91	33†
Malt Sprouts.						
European (No. 94), - - - -	9	75	81	68	76	64
American (No. 27), - - - -	1	67	80	—	68	33
Factors used in table 52, - -	—	—	81	68	76	64
Brewers' Grains.						
European (Nos. 95 and 96), -	9	62	69	81	63	39
Factors used in table 52, - -	—	—	69	81	63	39
Wheat Bran and Middlings.						
European (No. 87), - - - -	48	71	78	72	76	30
American (No. 29), - - - -	6	68	78	76	72	—
Factors used in table 52, - -	—	—	78	76	72	33†
Cotton Seed Meal.						
European (No. 105), - - - -	4	81	87	95	76	—
American (No. 28), - - - -	2	81	89	100	68	—
Factors used in table 52, - -	—	—	89	100	68	33†
Linseed Meal.						
European (No. 98), - - - -	10	81	86	90	80	50
Factors used in table 52, - -	—	—	86	90	80	50

* Assumed. † American figures were so low European were used. (See corn and cob meal.

THE CALCULATION OF RATIONS.

BY CHAS. D. WOODS.

In the preceding pages there have been summarized the results of analyses of the principal feeding stuffs used in New England and the results of digestion experiments showing in how far the animals are able to digest the nutrients furnished them in the different foods. It is only a few years since this subject was first introduced into America. The first at all full explanation of the composition and the digestibility of feeding stuffs and feeding standards ever given on this side of the Atlantic, or indeed in the English language, was presented before the winter meeting of the Connecticut State Board of Agriculture less than twenty years ago.* Since that time, many of our best farmers have come to a pretty clear understanding of the German feeding standards, and have learned to calculate the amounts of nutrients in the rations which they feed their stock. Perhaps, on the whole, those of us who have adopted these ideas have taken the matter a little too seriously, since there is danger of assuming that feeding standards are absolute, and that the calculations of a ration are merely questions of arithmetic.

At the present, the value of any food used in cattle-feeding is usually estimated by calculations based upon (*a*) more or less perfect knowledge of the chemical composition of the feeding stuff; that is, the percentages of protein, of fat, of carbohydrates, including fiber, and the ash; (*b*) upon the digestibility of these different ingredients in the class of food used, as observed in actual feeding experiments, and (*c*) upon the amounts of the digestible nutrients, as ascertained by feeding experiments and practical experience, which are needed for the proper nutrition of animals of different kinds, or fed for different purposes.

In table 48, pp. 144–155, there are given the average percentage composition of New England feeding stuffs, and figures showing

*Results of late European Experiments on the Feeding of Cattle, by W. O. Atwater, Report Connecticut Board of Agriculture, 1874, pp. 131–180.

the range of variation in composition. It is, I suspect, customary for those who use such tables to calculate their rations by assuming the materials they use to be of average composition and average digestibility. The great variability in composition of feeding stuffs, which a glance at the table will show, points out the unwisdom of blindly assuming a given feeding material to be of average composition. If it were practicable, the best method, when deciding upon a ration to be used, would be to have analyses made of the materials to be fed; but since this is not generally practicable, the farmer is left largely to his own judgment as to the quality of the food. Tables showing the range in composition will help to a better estimate of the probable composition of a given feeding stuff, when used with a knowledge of conditions of growth, than can be obtained in any way except by actual analysis.

In estimating whether a feed is above or below the average composition and digestibility, some of the more important conditions affecting composition and digestibility should be taken into account. They may be summed up as follows:

Crops of grain, and fodder plants other than legumes, grown with nitrogenous fertilizers, will usually contain more protein than those grown with only mineral fertilizers.

Fodders are equally digestible, whether fed green or dry, provided there is no loss in curing.

Quick curing without overdrying, and with a minimum of handling, reduces loss of leaves and other fine portions of the plant. Hay thus cured will usually be richer in protein and in fats than if there is much loss in curing. The protein and fat are also more digestible in such hays than in those that are not carefully cured.

The method of preparation of a fodder, *i. e*, whether steamed before feeding or not, or whether fed hot or cold, so far as the experiments show, produces no effect upon the digestibility.

As a rule, the older the plant, the less percentages of protein and fat and the more of fiber it contains. Also, the protein, fats, and carbohydrates are less digestible in old than in young plants. This points out the importance of comparatively early cutting. Probably the best time for cutting most plants used for hay is when they are in early bloom.

Long keeping reduces digestibility and is attended by loss of actual dry matter.

The chief thing to be observed in the use of concentrated feeds is to keep the ration narrow and not to supply too large a quantity of fat. Practically it is probably unwise to feed a ration whose nutritive ratio is greater than that of one to seven, or at the most one to eight. Some of the more recent experiments with milch cows seem to indicate that even a narrower ration than the ordinary standard, 1 to 5.4, can be used with profit.

Reference has been made (p. 165) to the fact that there is more or less uncertainty attending the use of coefficients of digestibility, but as a good guess is a better guide than blind ignorance, so digestion factors help us to a much better understanding of the value of a food than is possible without an attempt to take digestibility into account. Because our facts are not sufficient to warrant absolutely definite conclusions, it does not follow that we should not live up to all the light we have. The coefficients of digestibility suggested in table 51, in which the average results obtained in European and American digestion experiments are compared, are perhaps as good as any we have as yet. Twenty years ago we had almost no knowledge of the composition of American feeding stuffs. The number of analyses were so few that no attempt was made to compile them for practical use. In the past twenty years nearly 5,000 specimens of American feeding stuffs have been analyzed, and we know within quite definite limits what the composition of any given feeding stuff is. It is to be hoped and expected that the next two decades will see such additions made to our knowledge of digestibility that we may then be able to speak as confidently of the coefficients of digestibility as we now do of percentages of total nutrients.

In table 52 the attempt is made to calculate the weights of the different digestible nutrients and the calories of potential energy which would be supplied by a pound of each of the different kinds of feed most used in Connecticut. The figures here given were obtained by multiplying the averages of the analyses of different feeding stuffs given in table 48, p. 144, by the factors (digestion coefficients) given in table 51, p. 166.

TABLE 52.

Weights of Total Organic Matter and of Digestible Nutrients and Calories of Potential Energy in Digestible Nutrients of One Pound of Different Feeding Stuffs of Average Composition and Digestibility.

KIND OF FEEDING STUFF.	Total Organic Matter.	DIGESTIBLE NUTRIENTS.*				
		Total Digestible Nutrients.	Protein.	Fat.	Carbo-hydrates.	Fuel Value.
Green Fodders at Cutting.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.
Barley fodder,	.223	.168	.026	.004	.138	320
Hungarian fodder,	.257	.196	.022	.005	.169	375
Corn fodder (dent),	.170	.129	.015	.004	.110	250
Corn fodder (flint),	.188	.143	.015	.005	.123	280
Corn fodder (sweet),	.122	.092	.010	.002	.080	175
Oat fodder,	.233	.177	.013	.003	.161	335
Orchard grass,	.274	.210	.021	.007	.182	405
Pearl millet,	.254	.194	.016	.003	.175	370
Red-top,	.319	.244	.017	.005	.222	465
Rye fodder,	.180	.137	.014	.009	.114	275
Timothy,	.300	.229	.019	.005	.205	440
Wheat fodder,	.242	.184	.021	.006	.157	355
Clover,	.194	.131	.026	.005	.100	255
Cow pea vines,	.151	.104	.019	.004	.081	205
Oat and pea fodder,	.179	.129	.024	.005	.100	250
Vetch,	.163	.108	.026	.003	.079	210
Vetch and oats,	.217	.157	.018	.005	.134	305
Corned Fodders and Hays.						
Blue (June) grass,	.855	.502	.062	.018	.422	975
Corn fodder,	.860	.589	.040	.011	.538	1120
Corn stover (stalks),	.762	.486	.027	.009	.450	925
Fowl meadow,	.800	.469	.057	.016	.396	910
Hungarian,	.701	.413	.039	.012	.362	800
Hay mixed grasses,	.809	.480	.042	.016	.422	930
Oat hay,	.819	.484	.042	.015	.427	935
Oat straw,	.805	.425	.019	.010	.396	815
Orchard grass,	.822	.483	.047	.018	.418	940
Red-top,	.844	.500	.044	.015	.441	965
Timothy,	.847	.502	.036	.015	.451	970
Timothy and red-top,	.816	.483	.040	.013	.430	930
Alfalfa,	.823	.474	.081	.009	.384	905
Clover (alsike),	.806	.467	.082	.015	.370	905
Clover (red),	.839	.485	.081	.010	.394	925
Rowen hay,	.787	.506	.084	.015	.407	975
Ensilage.						
Corn ensilage,	.192	.126	.008	.006	.112	250
Roots, Etc.						
Carrots,	.099	.090	.008	.002	.080	170
Mangolds,	.087	.080	.011	.001	.068	150
Pumpkins,	.133	.114	.027	.019	.068	255
Potatoes,	.199	.169	.012	.001	.156	315
Ruta-bagas,	.099	.090	.009	.002	.079	170
Turnips,	.088	.078	.008	.002	.068	150

* The factors (digestion coefficients) used are those of table 51.

TABLE 52.—*(Continued.)*

KIND OF FEEDING STUFF.	Total Organic Matter.	DIGESTIBLE NUTRIENTS.* Total Digestible Nutrients.	Protein.	Fat.	Carbo-hydrates.	Fuel Value.
Milling and By-Products.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.
Corn meal,	.836	.713	.070	.035	.608	1410
Corn and cob meal,	.858	.684	.066	.031	.587	1345
Pea meal,	.869	.692	.168	.006	.518	1300
Hominy chops,	.864	.694	.074	.068	.552	1450
Buffalo gluten feed,	.906	.774	.178	.100	.496	1675
Chicago gluten meal,	.912	.794	.263	.082	.449	1670
Cream gluten,	.912	.803	.314	.130	.359	1800
Starch feed (wet),	.343	.264	.046	.025	.193	550
Oat feed,	.886	.762	.139	.062	.561	1565
Malt sprouts,	.841	.637	.188	.012	.437	1215
Brewers' grains (wet),	.233	.144	.037	.013	.094	300
Brewers' grains (dried),	.882	.550	.137	.045	.368	1130
Wheat bran,	.823	.568	.120	.030	.418	1130
Wheat middlings,	.846	.602	.122	.030	.450	1190
Cotton seed meal,	.846	.685	.376	.131	.178	1580
O. P. linseed meal,	.851	.681	.283	.071	.327	1435
N. P. linseed meal,	.841	.667	.286	.027	.354	1305

* The factors (digestion coefficients) used are those of table 51.

Keeping in mind that there is no such thing as a "best" ration, that individual animals vary in their needs, and in the extent to which they utilize the nutrients in their food, and that any one sample of a feeding stuff is generally either better or poorer than the average of all the samples of the same kind of feeding stuff that have been analyzed, we may venture to use such a table as the preceding (52).

As an illustration of the way such a table may be used, the detailed calculation of a ration follows.

At a farmers' institute, held in Bristol in the winter of 1893-4, a milkman, whose milk was tested by the Babcock method, said that he was feeding per 1000 pounds live weight as follows: Corn meal, 5 pounds; Buffalo gluten feed, 5 pounds; cotton seed meal, 2½ pounds; hay, 5 pounds; and ensilage, 40 pounds. Assuming the different feeding stuffs to be of average composition and digestibility, the ration may be calculated, from figures given in table 52, as follows:

EXAMPLE OF CALCULATING A RATION BY USE OF TABLE 52.

Kinds and Amounts of Feeding Stuffs Fed by a Bristol Milkman, and their Estimated Nutrients.

Feeding Stuff.		Digestible Nutrients.			
Kind.	Amount.	Protein.	Fat.	Carbohydrates.	Fuel Value.
	Lbs.	Lbs.	Lbs.	Lbs.	Calories.
Corn meal, - -	5	(.070×5) .350	(.035×5) .175	(.608×5) 3.040	(1410×5) 7050
Buffalo gluten feed,	5	(.178×5) .890	(.100×5) .500	(4.96×5) 2.480	(1675×5) 8375
Cotton seed meal, -	2½	(.376×2½) .940	(.131×2½) .328	(.178×2½) .444	(1580×2½) 3950
Hay, - - -	5	(.042×5) .210	(.016×5) .080	(.422×5) 2.110	(930×5) 4650
Ensilage, - -	5	(.008×40) .320	(.006×40) .240	(.112×40) 4.480	(250×40) 10,000
Total, - -	—	2.7	1.3	12.6	34,025
Nutritive ratio,* 1:	- - - - - -			$\frac{(1.3\times 2\frac{1}{2})+12.6}{2.7}=5.7$	

* Multiply the weight of digestible fat by two and a half, and add the product thus obtained to the weight of digestible carbohydrates and divide this sum by the weight of digestible protein. The quotient thus found is called the nutritive ratio.

Our knowledge of rations in general and for milch cows in particular, and its limitation, is referred to at some length in pages 94–101 of the present Report. Different as the "standards" for feeding milch cows, given in page 100, are from each other, it is probably true that 75 per cent. or more of the feeders of dairy stock in America would find that their herds would give better returns if they should try to make the rations which they feed conform to either of the four rations there suggested. This would follow not more from the improvement in the ration fed, than from the increased attention to details in care and handling which would follow better attention to feeding. The study of the individual animal which would be apt to be the outcome of this increased attention would doubtless, in most instances, result in an attempt to vary the ration of that particular animal so as to conform more nearly to its needs.

STUDIES OF DIETARIES.

BY H. B. GIBSON AND C. D. WOODS.

REPORTED BY W. O. ATWATER.

Accounts of studies of dietaries of families and a boarding house, by the Station, have been given in previous reports, as follows:

1. A boarding house.*
2. A chemist's family.*
3. A jeweler's family.†
4. A blacksmith's family.†
5. A machinist's family.†
6. A mason's family.†
7. A carpenter's family.†
8. A carpenter's family.†

Five dietaries have since been studied and are here reported. They are those of:

9. The family of the Station Agriculturist in winter.
10. A mason's family (the same as No. 6).
11. A carpenter's family (the same as No. 8).
12. A college students' club.
13. The family of the Station Agriculturist in summer.

The general plan of the investigation included an account of the amounts and composition of all food materials of nutritive value in the house at the beginning, purchased during and remaining at the end of the experiment, and of all the kitchen and table wastes. The amounts of different food materials on hand at the beginning and received during the experiment were added; from this sum the amounts remaining at the end were subtracted. This gave the amount of each material actually used. From the amount thus obtained and the composition of each material, as shown by analysis, the amounts of the nutritive ingredients were estimated. From these were subtracted the amounts of nutrients in the waste, and thus the amounts of nutrients actually eaten were learned.

Account was kept of the meals taken by the different members of the family, and by visitors. The number of meals for one man, to which the total number actual meals taken was equivalent, was estimated upon the basis of the potential energy, as has

* Report of this Station, 1891, pp. 90-106.
† Report of this Station, 1892, pp. 135-162.

been done in previous investigations here.* These energy equivalents, which are stated below, are somewhat arbitrary, and require revision in the light of accumulating inquiry. It has seemed best, however, to use the same figures here as in the previous reports and postpone the change until these dietaries may be summarized with others in a later publication.

Estimated Relative Quantities of Potential Energy in Nutrients Required by Persons of Different Classes.

Man at moderate work,	10
Woman at moderate work,	8
Child, 15 to 6 years old,	7
Child, 6 to 2 years old,	5
Child, under 2 years old,	2½

EXPLANATION OF TABLES.

The figures in the first table of each dietary (tables 53, 55, 57, 59 and 61), giving the actual amounts of food and of nutrients in the food used during the dietary, are based upon the weights of the food materials as they were purchased and used; that is, they include bone and other refuse, except where specified.

The first three columns in the table contain the percentages of protein, fat and carbohydrates used in computing the amounts of those nutrients in the different food materials. In all cases where the composition was not fairly well known from previous analyses, specimens of the food materials actually used in the dietary, or specimens as nearly identical as possible, were analyzed. The cases in which special analyses were made in connection with these dietaries are indicated in the table by placing the letter *a* after the name of the material. The weights of the water-free table and kitchen wastes, and their composition, are given in the last line of the table. Exactly what is included in these wastes is explained in the foot note on page 97 of the Report of this Station for 1891.

The third (last) table in each dietary (tables 54, 56, 58, 60 and 62) gives the nutrients and potential energy in food purchased, in table and kitchen wastes, and in the portion actually eaten. The estimates of animal and vegetable nutrients in the waste are computed as below described, and those of potential energy (fuel value of nutritive ingredients) as explained in an earlier Report.†

Table 63 summarizes the results of the thirteen dietary studies which have been made by the Station.

* See especially 17th Annual Report of the Massachusetts Bureau of Statistics of Labor, pp. 239-329.

† Report of this Station, 1890, p. 174.

DIETARY OF THE STATION AGRICULTURIST'S FAMILY IN WINTER.

The study began January 15, 1893 and continued 30 days.

The family was as follows:—

Man (agriculturist), 32 years old, light work.

Woman, 26 years old (assumed = .8 of one man).

Woman (servant), 35 years old (assumed = .8 of one man).

The meals taken were equivalent to 274 meals, or 91 days for one man.

TABLE 53.

Food Materials and Table and Kitchen Wastes in Dietary of the Station Agriculturist's Family During Thirty Days.

FOOD MATERIALS.	PERCENTAGE COMPOSITION.			WEIGHTS USED.			
					Nutrients.		
	Protein.	Fat.	Carbo-hydrates.	Total Food Materials.	Protein.	Fat.	Carbo-hydrates.
ANIMAL FOOD.	%	%	%	Grams.*	Grams.	Grams.	Grams.
Beef.							
Sirloin,	15.5	17.4	—	10,860	1,683	1,890	—
Round steak,	17.7	14.5	—	5,100	902	740	—
Shin,	13.6	1.4	—	2,240	305	31	—
Corned brisket,	13.7	31.1	—	2,890	396	899	—
Corned, canned,	26.7	17.1	—	540	144	236	—
Total,	—	—	—	21,630	3,430	3,796	—
Mutton, Etc.							
Part of leg mutton,	15.2	17.5	—	790	120	138	—
Fore quarter lamb,	14.7	21.0	—	2,500	368	525	—
Total,	—	—	—	3,290	488	663	—
Pork.							
Spare rib,	14.1	25.3	—	2,640	372	668	—
Lard,	—	99.8	—	2,040	—	2,036	—
Salted,	.9	82.8	—	80	1	66	—
Total,	—	—	—	4,760	373	2,770	—
Fish, Etc.							
Herring,	10.0	5.9	—	230	23	14	—
Cod,	10.6	.2	—	840	89	2	—
Haddock,	8.2	.2	—	880	72	2	—
Smelts,	10.0	1.0	—	740	74	7	—
Halibut,	15.1	4.4	—	680	103	3	—
Salmon, canned,	20.9	13.9	—	450	94	63	—
Oysters,	6.3	1.6	4.0	910	57	15	36
Total,	—	—	—	4,730	512	106	36

*100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 53.—*(Continued.)*

Food Materials.	Percentage Composition.			Weights Used.			
					Nutrients.		
	Protein.	Fat.	Carbo-hydrates.	Total Food Materials.	Protein.	Fat.	Carbo-hydrates.
ANIMAL FOOD.—*(Con.)* *Dairy Products, Etc.*	%	%	%	Grams.*	Grams.	Grams.	Grams.
Milk,	3.6	4.0	4.7	23,760	855	950	1,117
Cream,	2.5	18.8	4.1	500	13	94	20
Butter,	—	85.0	—	4,650	—	3,952	—
Total,	—	—	—	28,910	868	4,996	1,137
Eggs,	12.6	10.5	—	1,930	243	202	—
Total animal food,	—	—	—	65,250	5,914	12,533	1,173
VEGETABLE FOOD.							
Wheat flour *(a)*,	12.6	.9	74.2	17,720	2,233	159	13,148
Corn meal and samp,	9.2	3.8	70.6	1,770	163	67	1,480
Oat meal,	14.7	7.1	68.4	960	141	68	657
Wheat germs,	11.9	1.7	74.8	1,590	189	27	1,189
Rice and macaroni,	7.4	.4	79.4	540	40	2	429
Crackers,	9.3	13.1	69.0	1,560	145	204	1,076
Graham crackers,	9.8	13.6	69.7	450	44	61	314
Sugar,	—	—	100.0	10,770	—	—	10,770
Molasses,	—	—	72.0	2,040	—	—	1,469
Honey,	.8	—	77.9	680	5	—	462
Dried beans,	20.7	1.8	60.4	370	77	7	223
Potatoes (15 % refuse),	2.1	.1	17.9	26,070	547	26	2,060
Parsnips,	1.3	.7	16.2	3,250	42	23	526
Squash (edible),	.9	.2	10.1	4,900	44	10	495
Onions (edible),	1.4	.3	10.1	410	6	1	41
Turnips (edible),	1.2	.2	8.2	1,900	23	4	156
Apples (edible),	.3	.4	15.9	7,710	23	30	1,227
Total vegetable food,	—	—	—	82,690	3,722	689	35,722
Total animal and vegetable food purchased,	—	—	—	147,940	9,636	13,222	36,895
Table and kitchen wastes *(a)*,	35.0	28.9	32.4	1,963	687	567	636

* 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 54.

Nutrients and Potential Energy in Food Purchased, Rejected, and Eaten in Dietary of an Agriculturist's Family.

FOOD MATERIALS.		Nutrients. Protein.	Nutrients. Fat.	Nutrients. Carbo-hydrates.	Potential Energy.
		Grams.*	Grams.	Grams.	Calories.
For Family, 30 Days.					
Food purchased, -	Animal, - - -	5,914	12,533	1,173	145,610
	Vegetable, - -	3,722	689	35,722	168,130
	Total, - -	9,636	13,222	36,895	313,740
Waste, - - -	Animal, - - -	616	556	—	7,700
	Vegetable, - -	71	11	636	3,000
	Total, - -	687	567	636	10,700
Food actually eaten,	Animal, - - -	5,298	11,977	1,173	137,910
	Vegetable, - -	3,651	678	35,086	165,130
	Total, - -	8,949	12,655	36,259	303,040
Per Man, Per Day.					
Food purchased, -	Animal, - - -	65	137	13	1,590
	Vegetable, - -	41	8	392	1,860
	Total, - -	106	145	405	3,450
Waste, - - -	Animal, - - -	6	6	—	80
	Vegetable, - -	1	—	7	35
	Total, - -	7	6	7	115
Food actually eaten,	Animal, - - -	59	131	13	1,510
	Vegetable, - -	40	8	385	1,825
	Total, - -	99	139	398	3,335
Percentages of Total Food Purchased.					
Food purchased, -	Animal, - - -	61.4	94.8	3.2	46.4
	Vegetable, - -	38.6	5.2	96.8	53.6
	Total, - -	100.0	100.0	100.0	100.0
Waste, - - -	Animal, - - -	6.4	4.3	—	2.5
	Vegetable, - -	.7	—	1.7	.9
	Total, - -	7.1	4.3	1.7	3.4
Food actually eaten,	Animal, - - -	55.0	90.6	3.2	43.9
	Vegetable, - -	37.9	5.1	95.1	52.7
	Total, - -	92.9	95.7	98.3	96.6

* 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

DIETARY OF A MASON'S FAMILY.

The study began April 1, 1892, and continued twenty-eight days. The family (the same as in 6*) was as follows:—

Man about 28 years old (mason), at work three of the four weeks.

Woman of about same age (assumed = .8 of one man).

Child 1 year old (assumed = .25 of one man).

The meals taken were equivalent to 168 meals, or 56 days for one man.

TABLE 55.

Food Materials and Table and Kitchen Wastes in Dietary of a Mason's Family during Twenty-eight Days.

FOOD MATERIALS.	PERCENTAGE COMPOSITION.			WEIGHTS USED.			
					Nutrients.		
	Protein.	Fat.	Carbo-hydrates.	Total Food Materials.	Protein.	Fat.	Carbo-hydrates.
ANIMAL FOOD.	%	%	%	Grams.†	Grams.	Grams.	Gr'ms.
Beef.							
Round steak, free from bone,	19.0	13.6	—	1,900	361	258	—
Shoulder clod, - - -	17.0	13.7	—	2,130	362	292	—
Shank, free from bone, -	22.7	2.3	—	450	102	10	—
Shank, with bone, - -	13.6	1.4	—	1,980	269	28	—
Bologna sausage, - -	18.6	15.8	.2	950	177	150	2
Total, - - - - -	—	—	—	7,410	1,271	738	2
Veal.							
Shoulder, - - - - -	16.6	8.7	—	2,000	532	174	—
Pork.							
Chops, - - - - -	14.1	25.3	—	2,760	389	698	—
Shoulder, - - - - -	13.5	30.4	—	2,070	279	629	—
Pigs' feet, pickled, - -	10.7	10.1	—	1,930	207	195	—
Sausage, - - - - -	12.2	42.4	1.3	500	61	212	6
Salt pork, - - - -	.9	82.8	—	1,390	12	1,151	—
Lard, - - - - -	—	99.8	—	710	—	708	—
Total, - - - - -	—	—	—	9,360	948	3,593	6
Fish, Etc.							
Canned salmon, - - -	20.9	13.9	—	1,400	293	195	—
Fresh cod, - - - -	10.6	.2	—	450	48	1	—
Salt cod, - - - - -	16.0	.4	—	450	72	2	—
Sardines and anchovies, -	25.3	12.7	—	910	230	116	—
Total, - - - - -	—	—	—	3,210	643	314	—

* Report of this Station, 1892, pp. 158-161.

† 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 55.—*(Continued.)*

Food Materials.	Percentage Composition.			Weights Used.			
					Nutrients.		
	Protein.	Fat.	Carbo-hydrates.	Total Food Materials.	Protein.	Fat.	Carbo-hydrates.
ANIMAL FOOD.—*(Cont'd.)*	%	%	%	*Grams.	Grams.	Grams.	Grams.
Dairy Products, Etc.							
Whole milk *(a)*,	3.8	4.0	5.1	17,320	658	693	883
Skim milk *(a)*,	2.4	.3	4.1	25,230	606	76	1,034
Butter,	—	85.0	—	1,590	—	1,352	—
Cheese,	28.0	35.3	2.1	610	171	215	13
Total,	—	—	—	44,750	1,435	2,336	1,930
Eggs,	12.6	10.5	—	4,550	573	478	—
Total animal food,	—	—	—	71,280	5,402	7,633	1,938
VEGETABLE FOOD.							
Wheat flour *(a)*,	13.0	.8	73.4	5,410	703	43	3,971
Rye flour *(a)*,	8.8	1.0	77.6	2,350	207	24	1,824
Buckwheat *(a)*,	7.1	1.0	73.4	240	17	2	176
Oatmeal,	15.2	7.0	68.7	140	21	10	96
Starches,	—	—	97.8	850	—	—	831
Milk crackers,	9.3	13.1	69.2	1,870	174	245	1,294
Cookies,	8.3	10.8	57.6	1,120	93	121	645
Sugar,	—	—	100.0	5,480	—	—	5,480
Canned corn,	3.0	1.3	22.2	1,280	38	17	284
Potatoes (15 % refuse),	2.1	.1	17.9	15,440	324	15	2,764
Turnips (30 % refuse),	1.2	.2	8.2	1,140	14	2	93
Raisins,	2.7	.7	71.6	1,470	40	10	1,103
Total vegetable food,				36,790	1,631	489	18,561
Total animal and vegetable food,	—	—	—	108,070	7,033	8,122	20,499
Table and kitchen wastes *(a)*,	16.8	25.7	52.6	1,873	315	481	985

* 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 56.

Nutrients and Potential Energy in Food Purchased, Rejected, and Eaten in Dietary of a Mason's Family.

Food Materials.		Nutrients. Protein.	Fat.	Carbo-hydrates.	Potential Energy.
For Family, 28 Days.		Grams.*	Grams.	Grams.	Calories.
Food purchased,	Animal,	5,402	7,633	1,938	101,080
	Vegetable,	1,631	489	18,561	87,335
	Total,	7,033	8,122	20,499	188,415
Waste,	Animal,	228	455	—	5,165
	Vegetable,	87	26	985	4,635
	Total,	315	481	985	9,800
Food actually eaten,	Animal,	5,174	7,178	1,938	95,915
	Vegetable,	1,544	463	17,576	82,700
	Total,	6,718	7,641	19,514	178,615
Per Man, Per Day.					
Food purchased,	Animal,	96	136	35	1,805
	Vegetable,	29	9	331	1,560
	Total,	125	145	366	3,365
Waste,	Animal,	4	8	—	90
	Vegetable,	2	—	18	85
	Total,	6	8	18	175
Food actually eaten,	Animal,	92	128	35	1,715
	Vegetable,	27	9	313	1,475
	Total,	119	137	348	3,190
Percentages of Total Food Purchased.					
Food purchased,	Animal,	76.8	94.0	9.5	53.6
	Vegetable,	23.2	6.0	90.5	46.4
	Total,	100.0	100.0	100.0	100.0
Waste,	Animal,	3.2	5.6	—	2.7
	Vegetable,	1.2	.3	4.8	2.5
	Total,	4.4	5.9	4.8	5.2
Food actually eaten,	Animal,	73.6	88.4	9.5	50.9
	Vegetable,	22.0	5.7	85.7	43.9
	Total,	95.6	94.1	95.2	94.8

* 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

DIETARY OF A CARPENTER'S FAMILY.

The study began April 29, 1893, and continued 28 days. The family (the same as in No. 8*) was as follows:—

Man (carpenter) about 35 years old, at work.
Woman of about same age (assumed = .8 of one man).
Boy about 11 years old (assumed = .7 of one man).
The meals taken were equivalent to 210 meals, or 70 days for one man.

TABLE 57.

Food Materials and Table and Kitchen Wastes in Dietary of a Carpenter's Family during Twenty-eight Days.

FOOD MATERIALS.	PERCENTAGE COMPOSITION.			WEIGHTS USED.			
					Nutrients.		
	Protein.	Fat.	Carbo-hydrates.	Total Food Materials.	Protein.	Fat.	Carbo-hydrates.
ANIMAL FOOD.	%	%	%	Grams.†	Grams.	Grams.	Grams.
Beef.							
Sirloin,	15.5	17.4	—	5,760	893	1,002	—
Cooked and canned,	26.7	17.1	—	2,440	652	417	—
Corned rump,	16.7	8.6	—	1,390	232	120	—
Rump,	13.7	31.1	—	1,980	271	616	—
Liver,	20.1	5.4	3.5	1,460	294	79	51
Dried beef,	28.8	4.4	1.4	60	17	3	1
Total,	—	—	—	13,090	2,359	2,237	52
Pork.							
Salted,	.9	82.8	—	570	5	472	—
Ham,	14.8	34.6	—	2,880	426	996	—
Lard,	—	99.8	—	1,560	—	1,557	—
Total,	—	—	—	5,010	431	3,025	—
Fish, Etc.							
Salt cod,	10.6	.2	—	1,160	123	2	—
Canned salmon,	20.9	13.9	—	1,400	293	195	—
Canned clams,	10.4	.8	3.0	470	49	4	14
Total,	—	—	—	3,030	465	201	14
Dairy Products, Etc.							
Whole milk *(a)*,	3.6	3.8	3.2	15,600	562	593	499
Skim milk *(a)*,	2.4	.1	5.1	31,070	745	31	1,585
Butter,	—	85.0	—	1,570	—	1,335	—
Cheese,	28.0	35.3	2.1	160	45	57	3
Total,	—	—	—	48,400	1,352	2,016	2,087
Eggs,	12.6	10.5	—	3,390	427	356	—
Total animal food,	—	—	—	72,920	5,034	7,835	2,153

* Report of this Station for 1892, page 158.
† 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 57.—*(Continued.)*

FOOD MATERIALS.	PERCENTAGE COMPOSITION.			WEIGHTS USED.			
					Nutrients.		
	Protein.	Fat.	Carbohydrates.	Total Food Materials.	Protein.	Fat.	Carbohydrates.
VEGETABLE FOOD.	%	%	%	Grams.*	Grams.	Grams.	Grams.
Flour *(a)*,	11.0	1.1	74.9	2,180	240	24	1,633
Rex wheat *(a)*,	11.4	2.1	74.5	140	16	3	104
Starch, etc.,	—	—	97.8	110	—	—	108
Wheat bread,	9.1	1.6	56.0	17,410	1,584	279	9,750
Cake,	8.3	10.8	57.8	4,090	340	442	2,364
Crackers,	9.3	13.1	69.2	1,130	105	148	782
Sugar,	—	—	100.0	980	—	—	980
Potatoes (15 % refuse),	2.1	.1	17.9	33,110	695	33	5,927
Spinach,	2.1	.5	3.1	1,010	21	5	31
Canned squash,	1.1	.5	9.9	1,020	11	5	101
Canned peas,	4.2	.4	11.4	770	32	3	88
Dried apricots,	2.3	.5	66.5	230	5	1	153
Total vegetable food,	—	—	—	62,180	3,049	943	22,021
Total animal and vegetable food,	—	—	—	135,100	8,083	8,777	24,174
Table and kitchen wastes *(a)*,	24.7	18.1	51.6	1,319	326	239	681

* 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 58.

Nutrients and Potential Energy in Food Purchased, Rejected, and Eaten in Dietary of a Carpenter's Family.

Food Materials.		Nutrients. Protein.	Nutrients. Fat.	Nutrients. Carbo-hydrates.	Potential Energy.
		Grams.*	Grams.	Grams.	Calories.
For Family, 28 Days.					
Food purchased, -	Animal, - - -	5,034	7,835	2,153	102,330
	Vegetable, - -	3,049	942	22,021	111,550
	Total, - - -	8,083	8,777	24,174	213,880
Waste, - - -	Animal, - - -	232	210	—	2,900
	Vegetable, - -	94	29	681	3,450
	Total, - - -	326	239	681	6,350
Food actually eaten,	Animal, - - -	4,802	7,625	2,153	99,430
	Vegetable, - -	2,955	913	21,340	108,100
	Total, - - -	7,757	8,538	23,493	207,530
Per Man, Per Day.					
Food purchased, -	Animal, - - -	72	112	31	1,460
	Vegetable, - -	43	13	315	1,595
	Total, - - -	115	125	346	3,055
Waste, - - -	Animal, - - -	3	3	—	40
	Vegetable, - -	1	—	10	50
	Total, - - -	4	3	10	90
Food actually eaten,	Animal, - - -	69	109	31	1,420
	Vegetable, - -	42	13	305	1,545
	Total, - - -	111	122	336	2,965
Percentages of Total Food Purchased.					
Food purchased, -	Animal, - - -	62.3	89.3	8.8	47.8
	Vegetable, - -	37.7	10.7	91.2	52.2
	Total, - - -	100.0	100.0	100.0	100.0
Waste, - - -	Animal, - - -	3.6	2.4	—	1.4
	Vegetable, - -	1.5	.3	1.4	1.6
	Total, - - -	5.1	2.7	1.4	3.0
Food actually eaten,	Animal, - - -	58.7	86.9	8.8	46.4
	Vegetable, - -	36.2	10.4	89.8	50.6
	Total, - - -	94.9	97.3	98.6	97.0

*100 grams=3.5 ounces, or .22 pounds. 1 ounce=28.35 grams. 1 pound=453.6 grams.

DIETARY OF A COLLEGE CLUB.

The study began April 13, 1893, and continued 28 days.
The family was as follows:—
Twenty-seven students in college (2,154 meals).
Two women at moderate exercise (each assumed = .8 of one man).
Two servants (each assumed = .8 of one man).
The meals taken were equivalent to 2,421 meals, or 807 days for one man.

TABLE 59.

Food Materials and Table and Kitchen Wastes in Dietary of a College Club During Twenty-eight Days.

FOOD MATERIALS.	PERCENTAGE COMPOSITION.			WEIGHTS USED.			
					Nutrients.		
	Protein.	Fat.	Carbohydrates.	Total Food Materials.	Protein.	Fat.	Carbohydrates.
ANIMAL FOOD.	%	%	%	*Grams.	Grams.	Grams.	Grams.
Beef.							
Sirloin *(a)*,	16.9	15.9	—	37,930	6,410	6,031	—
Ribs *(a)*,	14.6	25.3	—	21,830	3,187	5,523	—
Shoulder clod,	17.0	13.7	—	14,000	2,380	1,918	—
Shoulder clod free from bone *(a)*,	20.9	6.4	—	23,130	4,834	1,480	—
Rump,	13.7	31.1	—	7,120	975	2,214	—
Round steak *(a)*,	17.4	16.6	—	18,230	3,172	3,026	—
Corned rump *(a)*,	16.7	12.1	—	13,380	2,234	1,619	—
Canned, corned,	26.7	17.1	—	1,810	483	310	—
Liver,	20.1	5.4	3.5	1,470	295	79	51
Dried beef,	28.8	4.4	1.4	880	253	39	12
Total,	—	—	—	139,780	24,223	22,239	63
Veal.							
Shoulder *(a)*,	14.8	11.9	—	11,310	1,674	1,346	—
Loin *(a)*,	14.6	15.5	—	13,610	1,987	2,110	—
Cutlets *(a)*,	20.2	10.1	—	9,580	1,935	968	—
Total,	—	—	—	34,500	5,596	4,424	—
Mutton.							
Chops *(a)*,	13.7	28.0	—	12,250	1,678	3,430	—
Leg *(a)*,	15.5	19.3	—	15,710	2,435	3,032	—
Loin *(a)*,	12.6	29.5	—	4,280	539	1,263	—
Total,	—	—	—	32,240	4,652	7,725	—
Pork.							
Ham,	14.8	34.6	—	17,580	2,602	6,083	—
Salt,	.9	82.8	—	850	8	704	—
Sausage *(a)*,	12.1	41.6	.9	8,700	1,053	3,619	78
Chops,	14.1	25.3	—	3,520	496	891	—
Lard *(a)*,	—	99.8	—	30,130	—	30,070	—
Total,	—	—	—	60,780	4,159	41,367	78
Fowl *(a)*,	11.2	7.2	—	8,590	962	618	—
Fish, etc.							
Oysters,	6.3	1.6	4.0	4,760	300	76	190
Haddock,	8.2	.2	—	3,300	271	7	—
Shad,	9.2	4.8	—	3,010	277	144	—
Shad roe,	20.9	3.8	2.6	540	113	21	14
Salt cod,	10.6	.2	—	540	57	1	—
Canned salmon *(a)*,	23.4	8.4	—	9,640	2,256	810	—
Total,	—	—	—	21,790	3,274	1,059	204
Dairy Products, etc.							
Milk *(a)*,	3.4	4.6	4.7	371,260	12,623	17,078	17,449
Butter *(a)*,	—	8.9	—	47,540	—	42,311	—

* 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 59.—*(Continued.)*

Food Materials.	Percentage Composition. Protein.	Fat.	Carbohydrates.	Weights Used. Total Food Materials.	Nutrients. Protein.	Fat.	Carbohydrates.
	%	%	%	*Grams.	Grams.	Grams.	Grams.
Cheese, - - - - -	28.0	35.3	2.1	480	134	169	10
Total, - - - -	—	—	—	419,280	12,757	59,558	17,459
Eggs, - - - - -	12.6	10.5	—	37,310	4,701	3,918	—
Total animal food, -	—	—	—	754,270	60,324	140,908	17,804
VEGETABLE FOOD.							
Bread flour *(a)*, - -	12.3	.7	74.6	117,230	14,419	821	87,454
Pastry flour *(a)*, - -	10.1	.9	75.7	44,450	4,489	400	33,648
Corn meal, - - -	9.2	3.8	70.6	2,470	227	94	1,744
Graham flour, - -	11.7	1.7	71.7	8,020	938	136	5,750
Oat meal *(a)*, - -	13.4	6.7	70.2	10,750	1,441	720	7,547
Bread, - - - - -	9.1	1.6	56.0	1,360	124	22	762
Ceraline *(a)*, - - -	9.4	1.0	78.6	3,010	283	30	2,366
Wheatlet *(a)*, - -	12.3	1.4	75.0	3,030	373	42	2,273
Rex wheat *(a)*, - -	11.4	2.1	74.5	3,630	414	76	2,704
Hominy, - - - -	8.3	.4	77.4	2,440	203	10	1,889
Rice, - - - - -	7.4	.4	79.4	1,760	130	7	1,397
Starch, - - - - -	—	—	97.8	3,660	—	—	3,579
Crackers, - - - -	9.3	13.1	69.2	5,670	527	743	3,924
Nonesuch mince meat *(a)*	4.0	2.2	67.4	2,610	104	57	1,759
Sugar, - - - - -	—	—	100.0	70,960	—	—	70,960
Molasses, - - - -	—	—	72.0	6,410	—	—	4,615
Dried beans *(a)*, - -	21.4	1.9	57.3	3,630	777	69	2,080
Onions (10 % refuse), -	1.4	.3	10.1	2,140	30	6	216
Cabbage (edible), - -	1.5	.2	4.6	1,810	27	4	83
Potatoes (30 % refuse), -	2.1	.1	17.9	166,240	3,491	166	29,757
Oranges and lemons, -	1.0	.9	8.3	34,710	347	312	2,881
Bananas (edible), - -	1.4	1.4	29.8	13,580	190	190	4,047
Pine apple (edible), -	.4	.3	9 7	4,420	18	13	429
Evaporated apples, etc., -	1.3	.8	68.3	4,650	60	37	3,176
Raisins, - - - - -	2.7	.7	71.6	2,670	72	19	1,912
Canned raspberries, cherries, peaches, etc., -	1.1	.8	11.4	27,950	307	224	3,186
Canned asparagus, - -	1.8	.2	3.3	3,970	71	8	131
Canned corn *(a)*, - -	3.0	1.2	21.9	6,970	209	84	1,526
Canned tomatoes, - -	1.0	.2	3.3	11,030	110	22	364
Canned squash *(a)*, -	1.1	.5	9.9	2,440	27	12	242
Canned string beans, -	4.1	.5	13.5	7,980	327	40	1,077
Lima beans *(a)*, - -	4.5	.5	17.0	5,790	261	29	984
Canned peas *(a)*, - -	4.1	.5	11.5	12,220	501	61	1,405
Total vegetable food, -	—	—	—	599,660	30,497	4,454	285,867
Total animal and vegetable food purchased,	—	—	—	1,353,930	90,821	145,362	303,671
Table & Kitchen Wastes (a)							
No. 387, - - - -	23.6	24.2	48.0	6,516	1,538	1,577	3,128
No. 391, - - - -	25.8	32.0	37.3	7,543	1,946	2,414	2,814
No. 394, - - - -	23.5	32.2	40.2	8,206	1,928	2,642	3,299
No. 401, - - - -	25.0	30.3	40.2	6,912	1,728	2,094	2,779
No. 404, - - - -	29.1	29.9	37.1	7,873	2,291	2,354	2,921
No. 408, - - - -	26.5	34.0	36.2	8,185	2,169	2,783	2,963
No. 410, - - - -	24.7	33.1	37.6	7,541	1,863	2,496	2,835
No. 411, - - - -	23.7	36.0	36.3	9,994	2,369	3,598	3,628
Fat, - - - - -	—	—	—	12,080	—	12,080	—
Total, - - - -	—	—	—	74,850	15,832	32,038	24,367

* 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 60.

Nutrients and Potential Energy in Food Purchased, Rejected, and Eaten in Dietary of a College Club.

FOOD MATERIALS.		Nutrients. Protein.	Nutrients. Fat.	Nutrients. Carbo-hydrates.	Potential Energy.
		Grams.*	Grams.	Grams.	Calories.
Food purchased,	Animal, - -	60,324	140,908	17,804	1,630,770
	Vegetable, -	30,497	4,454	285,867	1,338,515
	Total, - -	90,821	145,362	303,671	2,969,285
Waste, - - -	Animal, - -	13,232	31,658	—	348,670
	Vegetable, -	2,600	380	24,367	114,100
	Total, - -	15,832	32,038	24,367	462,770
Food actually eaten,	Animal, - -	47,092	109,250	17,804	1,282,100
	Vegetable, -	27,897	4,074	261,500	1,224,415
	Total, - -	74,989	113,324	279,304	2,506,515
Per Man, Per Day.					
Food purchased,	Animal, - -	75	174	22	2,020
	Vegetable, -	38	6	354	1,660
	Total, - -	113	180	376	3,680
Waste, - - -	Animal, - -	16	39	—	430
	Vegetable, -	3	—	30	140
	Total, - -	19	39	30	570
Food actually eaten,	Animal, - -	57	135	22	1,590
	Vegetable, -	35	6	321	1,520
	Total, - -	92	141	343	3,110
Percentages of Total Food Purchased.					
Food purchased, -	Animal, - -	66.4	96.9	5.9	54.9
	Vegetable, -	33.6	3.1	94.1	45.1
	Total, - -	100.0	100.0	100.0	100.0
Waste, - - -	Animal, - -	14.6	21.8	—	11.7
	Vegetable, -	2.9	.3	8.0	3.8
	Total, - -	17.5	22.1	8.0	15.5
Food actually eaten,	Animal, - -	51.8	75.1	5.9	43.2
	Vegetable, -	30.7	2.8	86.1	41.3
	Total, - -	82.5	77.9	92.0	84.5

*100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

DIETARY OF THE STATION AGRICULTURIST'S FAMILY IN SUMMER.

The study began July 7, 1893 and continued 31 days.

The family was the same as in the previous dietary, (page 176) except that the servant was away and a child 1 year old was included in the dietary.

The meals taken were equivalent to 171 meals, or 57 days for one man.

TABLE 61.

Food Materials and Table and Kitchen Wastes in Dietary of the Station Agriculturist's Family During Thirty Days.

FOOD MATERIALS.	PERCENTAGE COMPOSITION.			WEIGHTS USED.			
					Nutrients.		
	Protein.	Fat.	Carbo-hydrates.	Total Food Materials.	Protein.	Fat.	Carbo-hydrates.
ANIMAL FOOD.	%	%	%	Grams.*	Grams.	Grams.	Grams.
Beef.							
Rib,	12.2	27.9	—	4,220	515	1,177	—
Shin,	13.6	1.4	—	680	92	10	—
Round steak,	18.0	12.3	—	90	16	11	—
Sirloin,	15.0	16.4	—	450	68	74	—
Shoulder,	17.0	13.7	—	1,270	216	174	—
Canned tongue,	26.7	17.1	—	680	182	116	—
Tripe,	13.9	1.8	—	590	82	11	—
Total,	—	—	—	7,980	1,171	1,573	—
Veal.							
Steak,	20.2	10.1	—	1,040	210	105	—
Loin,	14.6	15.5	—	820	120	127	—
Liver,	20.1	5.4	3.5	1,410	283	76	49
Heart,	16.3	26.2	—	320	52	84	—
Tongue,	17.4	18.0	—	270	47	49	—
Total,	—	—	—	3,860	712	441	49
Lamb.							
Fore quarter,	18.1	25.8	—	1,810	328	467	—
Pork.							
Ham,	16.7	39.1	—	320	53	125	—
Chops,	14.1	25.3	—	320	45	81	—
Pork, salted,	.9	82.8	—	680	6	563	—
Lard,	—	99.8	—	180	—	180	—
Total,	—	—	—	1,500	104	949	—
Poultry.							
Chicken,	15.1	1.2	—	1,180	178	14	—

* 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 61.—(*Continued.*)

FOOD MATERIALS.	Percentage Composition. Protein.	Percentage Composition. Fat.	Percentage Composition. Carbo-hydrates.	Weights Used. Total Food Materials.	Weights Used. Nutrients. Protein.	Weights Used. Nutrients. Fat.	Weights Used. Nutrients. Carbo-hydrates.
Fish, Etc.	%	%	%	Grams.*	Grams.	Grams.	Grams.
Blue fish,	9.8	.6	—	910	89	5	—
Sword fish,	15.1	4.4	—	320	48	14	—
Weak fish,	8.4	1.1	—	820	69	9	—
Total,	—	—	—	2,050	206	28	—
Dairy Products.							
Milk,	3.6	4.0	4.7	44,720	1,610	1,789	2,102
Cream,	2.5	18.8	4.1	500	13	94	20
Butter,	—	85.0	—	2,590	—	2,202	—
Cheese,	28.0	35.3	2.1	540	151	191	11
Total,	—	—	—	48,350	1,774	4,276	2,133
Eggs,	12.6	10.5	—	3,130	394	329	—
Vegetable Foods.							
Flour (*a*),	13.1	.9	73.2	10,620	1,391	96	7,774
Corn meal,	9.2	3.8	70.6	270	25	10	191
Oat meal,	14.7	7.1	68.4	1,680	247	119	1,149
Wheat,	11.9	1.7	74.8	1,500	179	26	1,122
Rice and macaroni,	7.4	.4	79.4	770	57	3	611
Sugar,	—	—	100.0	8,210	—	—	8,210
Molasses,	—	—	72.0	540	—	—	389
Beets (edible),	1.1	.1	4.5	680	7	1	31
Onions (edible),	1.4	.3	10.1	1,320	18	4	133
Peas (edible),	4.4	.5	16.1	2,540	112	13	409
String beans (edible),	2.2	.4	9.5	540	12	2	51
Cauliflower (edible),	1.6	.8	5.0	770	12	6	39
Dried beans,	20.7	1.8	60.4	730	151	13	441
Squash (edible),	.9	.2	10.1	1,320	12	3	133
Potatoes (15 % refuse),	2.1	.1	17.9	13,690	287	14	2,451
Lettuce (edible),	1.6	.5	3.7	230	4	1	9
Cucumber (edible),	.8	.2	2.5	410	3	1	10
Green corn (edible),	2.8	1.1	14.2	540	15	6	77
Water melon (pulp),	.9	.7	6.2	6,940	62	49	430
Musk melon,	1.4	.2	20.5	450	6	1	92
Strawberries and raspberries,	1.0	.7	6.9	3,860	39	27	266
Whortleberries,	.7	3.0	13.5	770	5	23	104
Bananas (pulp),	1.4	1.4	29.8	1,000	14	14	298
Tomato (pulp),	.8	.4	2.5	1,770	14	7	44
Apple (pulp),	.3	.4	15.9	2,770	8	11	440
Total,	—	—	—	63,920	2,680	450	24,904
Total animal and vegetable foods purchased,	—	—	—	133,780	7,547	8,527	27,086
Table & kitchen wastes, *a*	33.4	39.4	23.4	799	267	315	187

* 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 62.

Nutrients and Potential Energy in Food Purchased, Rejected, and Eaten in Dietary of an Agriculturist's Family.

Food Materials.		Nutrients. Protein.	Nutrients. Fats.	Nutrients. Carbo-hydrates.	Potential Energy.
		Grams*	Grams.	Grams.	Calories.
Food purchased	Animal	4,867	8,077	2,182	104,015
	Vegetable	2,680	450	24,904	117,280
	Total	7,547	8,527	27,086	221,295
Waste	Animal	247	312	—	3,915
	Vegetable	20	3	187	875
	Total	267	315	187	4,790
Food actually eaten	Animal	4,620	7,765	2,182	100,100
	Vegetable	2,660	447	24,717	116,405
	Total	7,280	8,212	26,899	216,505
Per Man, Per Day.					
Food purchased	Animal	86	142	38	1,825
	Vegetable	47	8	437	2,060
	Total	133	150	475	3,885
Waste	Animal	4	5	—	70
	Vegetable	—	—	3	15
	Total	4	5	3	85
Food actually eaten	Animal	82	137	38	1,755
	Vegetable	47	8	434	2,045
	Total	129	145	472	3,800
Percentages of Total Food Purchased.					
Food purchased	Animal	64.5	94.7	8.1	47.0
	Vegetable	35.5	5.3	91.9	53.0
	Total	100.0	100.0	100.0	100.0
Waste	Animal	3.3	3.7	—	1.8
	Vegetable	.3	—	.7	.4
	Total	3.6	3.7	0.7	2.2
Food actually eaten	Animal	61.2	91.0	8.1	45.2
	Vegetable	35.2	5.3	91.2	52.6
	Total	96.4	96.3	99.3	97.8

* 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 63.

Summary of Results of Dietary Studies made by Station. Food per Man, per Day.

Dietaries.	Nutrients. Protein.	Fat.	Carbo-hydrates.	Potential Energy.
	Grams†	Grams.	Grams.	Calories
1. *Dietary of a Boarding House.**				
Food, Purchased,	126	188	426	4,010
Food, Waste,	23	36	25	520
Food, Eaten,	103	152	401	3,490
2. *Dietary of a Chemist's Family.**				
Food purchased, ‡	118	103	430	3,210
3. *Dietary of a Jeweler's Family.§*				
Food, Purchased,	91	126	483	3,530
Food, Waste,	8	9	5	140
Food, Eaten,	83	117	478	3,390
4. *Dietary of a Blacksmith's Family.§*				
Food, Purchased,	103	176	408	3,730
Food, Waste,	3	5	7	90
Food, Eaten,	100	171	401	3,640
5. *Dietary of a Machinist's Family.§*				
Food, Purchased,	100	159	427	2,640
Food, Waste,	1	3	6	60
Food, Eaten,	99	156	421	3,580
Two Dietaries of a Mason's Family.§				
6. December, 1892.				
Food, Purchased,	107	153	391	3,470
Food, Waste,	3	5	16	120
Food, Eaten,	104	148	375	3,350
10. May, 1893.				
Food, Purchased,	125	145	366	3,365
Food, Waste,	6	8	18	175
Food, Eaten,	119	137	348	3,190
Average of 6 and 10.				
Food, Purchased,	116	149	379	3,420
Food, Waste,	5	6	17	150
Food, Eaten,	111	143	362	3,270
7. *Dietary of a Carpenter's Family.§*				
Food, Purchased,	125	152	498	3,970
Food, Waste,	11	17	23	300
Food, Eaten,	114	135	475	3,670

TABLE 63.—*(Continued.)*

Dietaries.	Nutrients. Protein.	Fat.	Carbo-hydrates.	Potential Energy.
Two Dietaries of a Carpenter's Family. §	Grams†	Grams.	Grams.	Calories
8. November, 1892.				
Food, Purchased,	107	161	408	3,610
Food, Waste,	7	12	20	220
Food, Eaten,	100	149	388	3,390
11. May, 1893.				
Food, Purchased,	115	125	346	3,055
Food, Waste,	4	3	10	90
Food, Eaten,	111	122	336	2,965
Average of 8 and 11.				
Food, Purchased,	111	144	377	3,335
Food, Waste,	6	8	15	150
Food, Eaten,	105	135	362	3,185
Two Dietaries of Station Agriculturist's Family.				
9. Winter, 1893.				
Food, Purchased,	106	145	405	3,450
Food, Waste,	7	6	7	115
Food, Eaten,	99	139	398	3,335
13. Summer, 1893.				
Food, Purchased,	133	150	475	3,885
Food, Waste,	4	5	3	85
Food, Eaten,	129	145	472	3,800
Average of 9 and 13.				
Food, Purchased,	120	147	440	3,670
Food, Waste,	6	5	5	100
Food, Eaten,	114	142	435	3,570
12. *Dietary of a Students' Club.*				
Food, Purchased,	113	180	376	3,680
Food, Waste,	19	39	30	570
Food, Eaten,	92	141	343	3,110
Food eaten, Minimum of above,	83	103	336	2,965
Food eaten, Maximum of above,	129	171	478	3,800
Food eaten, Average of above,	**105**	**140**	**405**	**3,395**
Dietary Standards for Men at Moderate Work.				
Voit (German),	118	56	500	3,060
Atwater (American),	125	125	450	3,560

* Report of this Station, 1892, pages 135–162.
† 100 grams = 3.5 ounces, or .22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.
‡ There was very little waste in this dietary.
§ Report of this Station, 1891, pages 90–106.

DIETARY STUDIES IN THE UNITED STATES AND ELSEWHERE.

In the Report of this Station for 1892 considerable space was devoted to the subjects of food and dietaries. In the Report for 1892 was a short chapter on "Economy of Food." Bulletin No. 7 of the Station treated of similar subjects. The favor with which these publications have been received has been most encouraging. Among the evidences that such inquiry is coming to be regarded as most useful, is the fact that the Secretary of Agriculture has recommended to Congress an appropriation of $10,000 for the study of the subject by the Department of Agriculture in connection with the experiment stations and otherwise, and that the Office of Experiment Stations of that Department has undertaken the compilation of results of inquiries in this country and in Europe regarding the economy of food.

In connection with this compilation, which has been placed in my charge, I have, with the aid of Drs. H. B. Gibson and C. F. Langworthy, endeavored to collate the results of the studies of dietaries made in this direction up to the present time. We have found records of the examination of 491 separate dietaries, exclusive of army rations. The most of these have been made in Europe. The earliest date back to 1851. The majority have been made during the past 15 years and by far the larger number of the most reliable ones during the past 10 years. The people whose dietaries have been studied have been of various classes, ages and occupations. A few were in professional life and were decidedly well-to-do. The most were wage workers; some of these were very poor, but the larger number were in reasonably comfortable circumstances as compared with the majority of people of like occupation in the countries where they lived.

From the 491 dietaries we have selected 338 as accurate enough to warrant their use in drawing inferences. The number of persons whose food consumption was observed in each dietary of this selected list varied from a single individual to several hundred. The time of observation in each case was from one to thirty days. This list of 338 we have divided in two classes, the first including all the studies that seem to us reasonably accurate and complete; the second including those which are less accurate, but sufficiently so to allow their results to be included in the general averages. The classification of all these dietaries by countries and by completeness of detail is summarized in the following tabular statement.

Number of Dietaries Collated.

Classified by Countries and by completeness of detail.

A. Reasonably accurate and complete. B. Less accurate, but included in averages. C. Not included in averages.

	A	B	C	A+B	A+B+C
EUROPE.					
England,	—	7	49	7	56
Scotland, Wales and Ireland,	—	—	9	—	9
France,	—	1	5	1	6
Belgium,	—	—	15	—	15
Denmark and Sweden,	15	—	—	15	15
Russia,	4	25	—	29	29
Germany,	54	97	35	151	186
Austria,	—	3	—	3	3
Switzerland,	2	—	10	2	12
Italy,	15	—	15	15	30
Spain and Portugal,	—	—	6	—	6
Total, Europe,	90	133	144	223	367
ASIA.					
India,	—	—	7	—	7
Java,*	1	—	—	1	1
Japan,	8	5	1	13	14
Total, Asia,	9	5	8	14	22
CANADA.	—	13	—	13	13
UNITED STATES.					
Massachusetts,	—	19	—	19	19
Connecticut,	13	5	1	18	19
Penn., Philadelphia,	—	25	—	25	25
Ill., Chicago,	—	26	—	26	26
Total, United States,	13	75	1	88	89
Total, North America,	13	88	1	101	102
Grand Total,	112	226	153	338	491

*Java Village, World's Fair, Chicago.

It will be observed that of the 338 dietaries of the first two classes, 101 were made in the United States and Canada, of which 38 were in New England, 25 in Philadelphia, and 26 in Chicago. All of these were observed during the past eight years, and all but those in the two cities last named were studied by the writer and his assistants at Wesleyan University in coöperation with the Massachusetts Bureau and the U. S. Department of Labor, and as part of the work of the Storrs Experiment Station.

Of the European dietaries in the selected list, only seven are from England; those were determined by Playfair some 30 years ago. Only one comes from France, 15 are from Sweden and Denmark, and 29 from Russia. From Germany are 151, of which the earliest were by Liebig and a very large number are by Voit and his followers. From Italy are 15, of which eight are by Manfredi and six by Albertoni and Novi; these 14 include some of the latest and most thoroughly studied of all. From Japan are 13, all of which have been made lately by Germans connected with the University of Tokio and by Japanese working with them. One was the dietary of Javanese in the Java village at the World's Fair; this was studied in connection with the examinations of foods made under the direction of the writer and referred to on page 14 of this Report.

My object in citing these statistics is to call attention to the fact that this kind of inquiry is to-day well under way in several parts of the world. It represents the beginning of a science, that of the comparative nutrition of mankind, the comparisons being made by race, class, occupation, income, and social condition.

This investigation of the habits of food consumption is a branch of the general science of nutrition. It represents the broad, practical, humanitarian side of that science. The facts it seeks to find out and set in order are of the greatest importance. In connection with the coördinate facts of housing, clothing, occupation, income, and expenditure, and the like, they belong to the fundamental data of the great problem of human living. They are indispensable for the right understanding of the status of the different classes and races of men and the ways of elevating them.

The other side of the science of nutrition comes more fully within the domain of chemistry, physics and physiology; it begins with the study of food and the ways it is used in the body; it culminates in the study of the laws of the conservation of matter and of energy, and their application to the living organism. An effort in this last direction is being made in the development of the respiration calorimeter to which reference was made on page 16 of this Report.

The study of food and dietaries has an intensely practical side. It comes home to every household and to every person. It is most intimately connected with our health and our strength for work, for our bodies are built up and kept in repair by our food, and food gives us power for the labor of hand and brain. It reaches

deep into the purse, for half the earnings of the wage workers of Connecticut, as of the rest of Christendom, are spent and must be spent for food.

The results of examinations of dietaries which are cited in detail in this article, represent a part of a series of observations which are being carried on year after year. Some of the practical applications were given in the two previous Annual Reports of the Station, namely those for 1891 and 1892. In an article in the latter on The Economy of Food, considerable space was given to the practical aspect of the subject in its bearing upon personal and household economy. It is hoped that future publications will contain still more information of practical as well as theoretical interest.

IMMEDIATE PRACTICAL APPLICATIONS. AGRICULTURAL BEARINGS OF THE SUBJECT.

In closing, I may recapitulate in a few words some of the practical bearings of the subject. Scientific research, interpreting the observations of practical life, indicates that we make a fourfold mistake in our food economy.

First, we purchase needlessly expensive kinds of food. We do this under the false impression that there is some peculiar virtue in the costlier food materials, and that economy in our diet is somehow detrimental to our dignity or our welfare. And, unfortunately, those who are most extravagant in this respect are often the ones who can least afford it.

Secondly, the food which we eat does not always contain the proper proportions of the different kinds of nutritive ingredients. We consume relatively too much of the fuel ingredients of food, such as the fats of meat and butter, the starch which makes up the larger part of the nutritive material of flour and potatoes, and sugar and sweetmeats. Conversely, we have relatively too little of the protein or flesh-forming substances, like the lean of meat and fish, and the gluten of wheat, which make muscle and sinew and which are the basis of blood, bone, and brain.

Thirdly, many people, not only the well-to-do, but those in moderate circumstances, use needless quantities of food. Part of the excess, however, is simply thrown away with the wastes of the table and kitchen; so that the injury to health, great as it may be, is doubtless much less than if all were eaten. Probably

the worst sufferers from this evil are well-to-do people of sedentary occupations—brain-workers as distinguished from hand-workers.

Finally, we are guilty of serious errors in our cooking. We waste a great deal of fuel in the preparation of our food, and even then a great deal of the food is very badly cooked. A reform in the methods of cooking is one of the economic demands of our time.

To the farmer the subject is of vital interest. The agricultural production of the United States is out of balance. Our food supply for man and beast contains an excess of the materials which serve the body for fuel, and are relatively deficient in the nitrogenous compounds which make blood, muscle, and bone. In other words, the farmer produces relatively too much starch, sugar, and other carbohydrates; too much fat and too little protein. The crops he grows are, taken together, deficient in protein, and the meat he makes is excessively fat. The one-sidedness of our food consumption is the natural result of the one-sidedness of our food production.

The remedy for the evil is in growing crops with more protein. The needed increase of protein may be obtained by use of nitrogenous manures, by breeding and importing varieties of grains and grasses richer in nitrogen than those we now cultivate, and by growing more legumes, such as clovers, alfafa, vetch, seradella, cow peas, peas, and beans.

The legumes do not require nitrogen in manure, but do well with the less expensive mineral fertilizers. They obtain nitrogen directly from the air and convert it into protein. The farmer needs this protein for fodder; by mixing the leguminous products with poor hay, straw, and cornstalks, which lack protein, the latter can be most profitably utilized. The food thus produced for stock is what is needed to make more meat and at the same time meat which will be tender and juicy without excess of fat, and to make more milk at less cost. The nitrogen not transformed into meat or milk makes rich manure for grasses, grains, and other crops. And finally, the richer manure helps to bring larger crops and crops richer in protein.

The error which causes the one-sidedness of our agricultural production brings cumulative ill; the means for amending it will bring cumulative good.

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